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COMPUTER BLAST DESIGN PROGRAMS FOR UNDERGROUND STOPES (USER MANUAL FOR PROGRAMS VCRM, LDBB and PGRAPH)

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by

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FOREWORD

Bulk mining methods are increasingly used in underground hard rock mines, where mining conditions are suitable. These have the advantage of permitting higher productivity at lower unit cost, compared with other methods, and with greater safety as miners do not work directly in the stopes being mined.

Bulk mining methods often involves the use of long length, large diameter holes for explosives. In carrying out blast design studies consideration must be given to the impact of hole deviation on charge size and sequence if blast optimization is to be achieved in terms of muck production and blast damage. Development of simulation models, which take into consideration hole deviation in determining fragmentation zones, fragmentation product and vibration levels, would be of advantage to mine engineers involved in bulk mining blast design.

With this objective in mind, MRL/CANMET managed a contract awarded by the Department of Supply and Services, Canada, to Mining Resource Engineering Ltd. (MREL) of Kingston, Ontario, to develop suitable simulation models. The models were developed in two stages: development and testing with available data of Vertical Crater Retreat (VCR) and Large Diameter Blasthole Benching (LDBB) simulation models, and; field testing of the simulation models through application. The simulation model programs were designed to run on an IBM PC-AT.

The present users manual was prepared by Messrs. P. Lacourse and R. Boyle of the Canadian Mine Technology Laboratory of CANMET's Mining Research Laboratories, through selective use of pertinent sections and materials contained in MREL's final contract report. As a user manual, it does not contain detailed information on the theoretical aspects of the models and simulation procedures contained within the contractors report. Those interested in acquiring a copy of the MREL report are referred to CANMET's Technical Information Division for further information.

It is CANMET's, as well as MREL's hope, that the programs will be useful to mine engineers involved in Vertical Crater Retreat and Large Diameter Blasthole Benching blasting design.

John E. Udd
Director
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AVANT-PROPOS

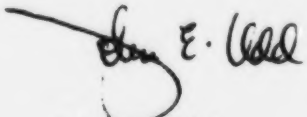
Les méthodes de minage en vrac sont de plus en plus utilisées dans les mines souterraines où les conditions s'y prêtent. En comparaison avec d'autres méthodes, celles-ci permettent une productivité accrue à un faible coût unitaire, tout en étant plus sécuritaires pour les mineurs qui n'ont pas à travailler dans les tailles en exploitation.

Les méthodes de minage en vrac impliquent souvent des forages long trou de grand diamètre. Afin d'optimiser le sautage en fonction de la production de roche brisée et des dommages causés par le sautage, la conception pour l'abattage doit considérer l'impact de la déviation du trou de forage, la charge des explosifs et la séquence de sautage. Le développement de modèles de simulation qui considèrent la déviation du trou de forage pour déterminer les zones de fragmentation, le roc fragmenté et les niveaux de vibration, serait avantageux pour les ingénieurs miniers chargés de la conception d'abattage en vrac.

Tenant compte de ces objectifs, LRM du CANMET a géré un contrat émis par le département d'Approvisionnements et Services Canada à Mining Resource Engineering Limited (MREL) de Kingston, Ontario, pour développer les modèles adéquats de simulation. Les modèles furent développés en deux étapes: développement et test des modèles de simulation par la méthode d'abattage verticale rabattante (VCRM) et par la méthode d'abattage par bancs (LDBB); et essai des modèles de simulation avec un cas réel. Les logiciels de simulation peuvent être exécutés sur un micro-ordinateur IBM PC/AT.

Le guide de l'usager a été préparé par Messieurs P. Lacourse et R. Boyle du Laboratoire canadien de technologie minière des Laboratoires de recherche minière du CANMET. Comme tout manuel de l'usager, il ne contient pas l'information détaillée sur la théorie des modèles et sur les procédures de simulation contenues dans le rapport du contracteur. Pour de plus amples informations, une copie du rapport de MREL peut être obtenue à la division de l'Information technologique du CANMET.

CANMET et MREL souhaitent que ce logiciel soit utile aux ingénieurs miniers impliqués dans la conception d'opérations basées sur la méthode d'abattage verticale rabattante et la méthode d'abattage par bancs.



John E. Udd
Directeur
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DISCLAIMERS

To the best knowledge of the contractor and Energy, Mines and Resources Canada the computer programs VCRM (Vertical Crater Retreat Method), LDBB (Large Diameter Blasthole Benching) and the graphics program (PGRAPH) will operate as represented. However, neither the contractor nor CANMET give any warranty, expressed or implied, as to the completeness of the documentation, or the performance of the programs.

The computer programs VCRM, LDBB and PGRAPH are protected by Crown Copyright.

For more information concerning the availability of these programs contact:

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COMPUTER BLAST DESIGN PROGRAMS FOR UNDERGROUND STOPES (USER MANUAL FOR PROGRAMS VCRM, LDBB AND PGRAPH)

by

Mining Resource Engineering Limited *, P. Lacourse **, R. Boyle ***

ABSTRACT

A user manual has been developed to facilitate the use of VCRM, LDBB and PGRAPH programs in bulk mining blast design in underground hard rock mines. The manual contains a description of input options and computer files required for execution of programs VCRM, LDBB, and PGRAPH. The manual also contains a detailed example of available input options and output results for the programs, VCRM, LDBB and PGRAPH as produced on a VAX 11/750 computer. The computer software blast design criteria is based on Livingston's crater theory. The computer software VCRM, LDBB and PGRAPH were written in Fortran 77. PGRAPH makes use of the graphic package GKS, Graphical Kernel System. The minimum hardware requirements for execution of the programs is an IBM PC/AT micro-computer, or compatible, with 640 Kbytes of memory.

Keywords: Computer blast design; computer software; graphics; user manual; VCRM, Vertical Crater Retreat Method; LDBB, Large Diameter Blasthole Benching; PGRAPH graphical representation of drillholes on graphics terminal.

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CONCEPTION ASSISTÉ PAR ORDINATEUR POUR L'ABATTAGE DE TAILLES SOUTERRAINES (MANUEL DE L'USAGER POUR LES PROGRAMMES VCRM, LDBB ET PGRAPH)

par

Mining Resource Engineering Limited *, P. Lacourse **, R. Boyle ***

RÉSUMÉ

Un manuel de l'usager a été développé pour faciliter l'utilisation des programmes VCRM, LDBB et PGRAPH. Ces programmes peuvent être utilisés pour la conception de l'abattage assisté par ordinateur dans les mines souterraines employant des méthodes de minage en vrac. Une description des options d'entrées et des fichiers d'ordinateur nécessaires pour l'exécution de ces programmes sont inclus dans le manuel. Un exemple détaillé produit sur un ordinateur de type VAX 11/750 avec les options d'entrées et les résultats des programmes VCRM, LDBB et PGRAPH sont aussi presentés dans ce manuel. Le logiciel pour la conception d'abattage assisté par ordinateur est tiré de la théorie des cratères de Livingston. Les logiciels VCRM, LDBB et PGRAPH ont été écrits en Fortran 77. PGRAPH utilise le logiciel graphique GKS, Graphical Kernel System. L'exécution de ces programmes requiert au minimum le matériel suivant: un micro-ordinateur IBM PC/AT; ou un micro compatible avec 640 Kbytes de mémoire.

MOT-CLÉS: conception assisté par ordinateur pour l'abattage, logiciel d'ordinateur; graphisme: manuel de l'usager; VCRM, méthode d'abattage verticale rabattante; LDBB, méthode d'abattage par bancs; PGRAPG, représentation graphique de trous de forage sur écran graphique.

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TABLE OF CONTENTS

	Page
FOREWORD	i
AVANT-PROPOS	ii
DISCLAIMERS	iv
ABSTRACT	v
RÉSUMÉ	vi
TABLE OF CONTENTS	vii
FIGURES	viii
1.1 INTRODUCTION	1
1.2 COMPUTER REQUIREMENTS	3
1.3 PROGRAMS INCLUDED ON DISKETTES	4
1.4 INPUT DATA	6
1.5 PROGRAM RESTRICTIONS	7
2. VCRM PROGRAM	9
2.1 DATA FILES FOR VCRM PROGRAM	10
2.1.1 YOURSTOP.DAT	10
2.1.2 YOUR.DAT	10
2.1.3 CRCURV.DAT	12
2.1.4 PCH3.DAT	12
2.1.5 RESTART.DAT	12
2.1.6 OUT.LST	12
2.2 TEST EXAMPLE OF VCRM PROGRAM	16
2.3 LISTING OF RESULTS AS STORED IN OUT.LST	21
3. LDBB Program	25
3.1 DATA FILES FOR LDBB PROGRAM	26
3.1.1 YOURBENC.DAT	26
3.1.2 YOUR2.DAT	26
3.1.3 TOP.DAT	27
3.1.4 BBLAST.DAT	27
3.1.5 BCURV.DAT	28
3.1.6 PCH3B.DAT	29
3.1.7 RESTART.DAT	29
3.1.8 DECKS.DAT	29
3.1.9 BBOUT.LST	29
3.2 TEST EXAMPLE OF LDBB PROGRAM	31
3.3 LISTING OF RESULTS AS STORED IN BBOUT.LST	39
4. PGRAPH PROGRAM	48
4.1 TEST EXAMPLE OF PGRAPH PROGRAM (PLAN)	51
4.2 TEST EXAMPLE OF PGRAPH PROGRAM (CROSS SECTIONS)	54

FIGURES

Page

Figure 1: Reference point location 13
Figure 2: Numbering of holes 14
Figure 3: Hole row and column numbering 15
Figure 4: Slot outline (BBLAST.DAT) 30
Figure 5: Plan of holes on elevation 10650.0 53
Figure 6: Cross section of holes on row 1 56
Figure 7: Cross section of holes on row 2 57
Figure 8: Cross section of holes on row 3 58
Figure 9: Cross section of holes on row 4 59
Figure 10: Cross section of holes on column 1 60
Figure 11: Cross section of holes on column 2 61
Figure 12: Cross section of holes on column 3 62
Figure 13: Cross section of holes on column 4 63
Figure 14: Cross section of holes on column 5 64

USER MANUAL FOR PROGRAMS
VCRM, LDBB and PGRAPH

1.1 INTRODUCTION

Large blast hole stoping methods are used increasingly in underground mines. Their use permits realization of the economies associated with large blast patterns and, as well, a reduction in operational delays and disruptions.

In order to further improve the economic benefits of these methods, the trend is towards using greater stope heights. In large-scale blasthole mining, preliminary stope development is normally carried out to accommodate the use of either the vertical crater retreat method (VCRM) or the large diameter bench blasting method (LDBB).

The VCRM method uses single charges in each hole, at optimum distances from the free face provided by the undercut, to crater into the open stope below. The LDBB method uses a suitably sequenced detonation of decked charges in vertical holes to break a vertical slice toward the developing stope opening.

The wandering of drill holes increases markedly with length and, thus, stope height. The deviations realized with 30m length holes, for hole sizes of 125mm and 150mm, do not seriously affect blast performance. Beyond 30m, however, blast hole deviation can affect blast performance; particularly in the lower section of the stope away from the drilling drift. Hole divergence from the planned direction can result in charge distributions which result in unacceptable burdens and fragmentation. There is even the possibility of charges firing out of sequence because of extreme hole deviation.

Two programs were developed to assist the design of large blast hole stopes:

1. VCRM, when the vertical crater retreat method is being used.
2. LDBB, when the blast hole benching method is being used.

The programs, originally developed to run on a mainframe computer, have been adapted to run on an IBM PC-AT.

PGRAPH is used to provide horizontal and vertical projections of the blast holes and stope profile.

For the user, VCRM and LDBB determine the optimum blast design parameters, taking into consideration the actual location of individual holes in relation to blast faces and specified acceptable vibration levels in adjacent areas.

Livingston's crater theory (Bauer. 1965 & Livingston. 1973) is used for fracture prediction.

1.2 COMPUTER REQUIREMENTS

The hardware, software and graphics requirements for the utilization of VCRM, LDBB and PGRAPH are the following:

1. VCRM and LDDB:
   (a) IBM PC AT, or equivalent, running under MS-DOS;
   (b) 640 Kbyte memory.
2. PGRAPH:
   (a) Fortran compiler;
   (b) Graphical Kernel System (GKS) with a Fortran binding for MS DOS;
   (c) mathematical coprocessor 8087;
   (d) graphics board;
   (e) graphic driver(s) for output device(s).

Please contact the Mineral Technology Information Officer for different hardware configuration than above. Within the next year it is anticipated that software will be available to run the program using the following systems:

1. VAX 11/750 computer with VMS 4.4 operating system;
2. SUN 3/160 computer with SUN OS operating system;
3. CDC Cyber 800 computer series with NOS/VE operating system.

1.3 PROGRAMS INCLUDED ON DISKETTES

Programs VCRM, LDBB and PGRAPH, with input test data and required files, are stored on four diskettes (a 1.2 Mbyte single disk version is also available).

- Diskette 1a contains the following files:
  - First part of VCRM.EXE (Executable version of the Vertical Crater Retreat Method program)
- Diskette 1b contains the following files:
  - Second part of VCRM.EXE
  - YOURSTOP.DAT
  - YOUR.DAT
  - PCH3.DAT, (data will be written to this file)
  - CRCURV.DAT, (data will be written to this file)
  - RESTART.DAT, direct access file of length 80 bytes, (input data provided to the program by the user will be written to this file)
  - OUT.LST, (output results will be written to this file)
- Diskette 2 contains the following files:
  - LDBB.EXE (Executable version of the Large Diameter Blasthole Benching program)
  - YOURBENC.DAT
  - YOUR2.DAT
  - TOP.DAT
  - BBLAST.DAT
  - PCH3B.DAT, (data will be written to this file)
  - BCURV.DAT, (data will be written to this file)
  - RESTART.DAT, direct access file of length 80 bytes, (data will be written to this file)

- DECKS.DAT. (data will be written to this file)
- BBOUT.LST. (output results will be written to this file)

• Diskette 3 contains the following Fortran source code files of the graphics program PGRAPH:

- CHAR.FOR
- COMMON.FOR
- INTEGER.FOR
- PANG.FOR
- PCROSN.FOR
- PGRAPH.FOR
- PLAN.FOR
- PTRANS.FOR
- REAL.FOR

The file VCRM.EXE does not fit on one diskette therefore, it was stored on two diskettes (1a and 1b) using the MS DOS command BACKUP. To copy VCRM.EXE to your hard disk use the following MS DOS command:

RESTORE A:VCRM.EXE C:

(for more information refer to MS DOS RESTORE command)

VCRM.EXE is stored in a new directory called CANMET.

1.4 INPUT DATA

The input data for the programs can be divided into five categories:

1. The following data related to the geometry of the blast:
   (a) The coordinates of at least two points on the axis of each blasthole. (Figure 1)
   (b) The diameter of the blasthole.
   (c) The location of the free face.
   (d) The coordinates of the points at which vibrations will be checked (for VCRM and LDBB only)
   (e) The coordinates of the points at which backbreak will be checked (LDBB only).
2. The following data related to Livingston's crater theory (for VCRM and LDBB):
   (a) Weight of charge and depth of contained charge during the tests to obtain cratering data.
   (b) Test explosives weight strength relative to AN/FO.
3. The following data related to the explosives used in the blast (VCRM and LDBB):
   (a) The density of the explosives.
   (b) The weight strength of each of the explosives relative to AN/FO.
4. The following data related to vibration level:
   (a) The site factor K and m for the formula:

$$V = K\left(\frac{R}{W^{\frac{1}{3}}}\right)^{m}$$

where:

V is the peak particle velocity (inch/sec)
R is the distance between the charge and the recording site (ft)
W is the weight of the charge (lbs)

K and m are site factors which must be determined at the particular mine site.

(b) The maximum acceptable peak particle velocity (inch/sec).

5. Initiation sequence data.

The following Imperial system units have been used in the programs:

Length: ft.
Mass: lbs.
Density: lbs./cu.ft.

with the following exceptions:

Borehole diameters are expressed in inches and explosive density in g/cc.

Most of the data are fed interactively in a user friendly environment. The user has to create the files related to the geometry of the stope.

Another feature of programs LDBB and VCRM is a restart file (RESTART.DAT). This file can be recalled and modified interactively.

Input is accepted in either upper or lower case.

1.5 PROGRAM RESTRICTIONS

Use of VCRM, LDBB and PGRAPH are subject to the following constraints:

1. VCRM

   (a) Maximum number of boreholes: 50

   (b) Maximum number of points along the axis of a hole at which measurements of coordinates are available: 20

   (c) Maximum number of points for vibrations checks: 10

2. LDBB

   (a) Maximum number of boreholes: 50

   (b) Maximum number of points along the axis of a hole at which measurements of coordinates are available: 20

(c) Maximum number of points for vibrations checks: 10

(d) Maximum number of explosives types: 10

(e) Maximum number of decks per hole: 10

(f) Maximum number of lines defining free face (BBLAST.DAT): 10

3. PGRAPH constraints are the same as for the previous programs.

2. VCRM PROGRAM

The VCRM program simulates a blast with each hole charged at optimum distance from free face. The free face is considered to be horizontal. Since this is not true in reality, an average should be used for the simulations. Extreme cases can also be simulated.

2.1 DATA FILES FOR VCRM PROGRAM

All data files are free formatted: a blank character is required between each value.

Before running VCRM, the following files must be created:

2.1.1 YOURSTOP.DAT

Information on the stope.

Line 1: Title (up to 80 characters)

Line 2: X, Y, Z coordinates of reference point. Coordinates are required for the conversion from global to local coordinates. The reference point should be located close to the blast and in such a way that the local X, Y coordinates of the blastholes are positive (figure 1).

Line 3: Stope length, width and depth (ft.). These data are used in the PGRAPH program and indicate the dimensions of the windows on which the plan views and cross-sections will be drawn.

Line 4: Angle of local axis X_l with respect to mine axis X_g (degrees, counter clockwise).

Example:

```
YOUR STOPE SAMPLE PROBLEM
     0.0        0.0    10545.0
    80.0       80.0      160.0
    00.0
```

2.1.2 YOUR.DAT

Coordinates of the holes at different elevations.

Line 1: The following information on first hole:

Hole number: The actual number of the hole . The sequence is not important. (see Figure 2)

Number of points: Number of points along the axis of the hole where coordinates were measured.

Row number: Number of the group of holes which are going to be projected to

the ZX plane when using the graphics program. (see Fig. 3)

Column number: Number of the group of holes which will be projected to the ZY plane when using the graphics program. (see Fig. 3)

Hole diameter: Diameter of the hole in inches.

Line 2: X,Y,Z coordinates of point 1, first hole.
Line 3: X,Y,Z coordinates of point 2, first hole.
Line N+1: X,Y,Z coordinates of point N, first hole.

The Z coordinate increases with depth.

Enter all holes in same manner.

Example:

```
 1    2    1    1      6.50
  16.25     40.00  10545.00
  16.25     18.75  10686.00
 2    2    2    1      6.50
  16.25     43.75  10545.00
  16.25     30.00  10675.00
 3    2    3    1      6.50
  16.25     46.25  10545.00
  16.25     40.00  10692.00
 4    2    4    1      6.50
  16.25     50.00  10545.00
  16.25     50.00  10692.00
 5    2    1    2      6.50
  31.25     41.25  10545.00
  31.25     18.75  10688.00
 6    2    2    2      6.50
  31.25     45.00  10545.00
  31.25     33.75  10675.00
 7    2    3    2      6.50
  31.25     48.75  10545.00
  31.25     48.75  10693.00
 8    2    1    3      6.50
  46.25     41.25  10545.00
  46.25     17.25  10690.00
 9    2    2    3      6.50
  46.25     36.25  10545.00
  46.25     35.00  10678.00
10    2    1    4      6.50
  61.25     45.00  10545.00
  61.25     20.00  10688.00
11    2    2    4      6.50
  61.25     46.25  10545.00
  61.25     36.25  10680.00
12    2    1    5      6.50
  76.25     41.25  10545.00
  76.25     17.50  10690.00
13    2    2    5      6.50
  76.25     45.00  10545.00
  76.25     37.50  10678.00
14    2    3    6      6.50
  39.00     41.00  10545.00
  39.00     41.00  10690.00
```

The following files must be opened before executing the program:

2.1.3 CRCURV.DAT

Definition of the cratering curves. This file can be created before running the main program or interactively while using it.

The Scaled crater depth and Scaled crater radius versus depth ratio curves are defined by two series of paired coordinates.

Example:

```
8                                  <-- Number of points for the Scaled crater depth VS depth ratio curve
0.6000    0.1400
0.7100    0.2000
0.8300    0.2200
1.0700    0.2700
1.5900    0.3400
0.8700    0.5000
0.5200    0.4900
0.3600    0.6100
8                                  <-- Number of points for the Scaled crater radius VS depth ratio curve
2.0000    0.1400
2.0200    0.2000
2.0300    0.2200
2.1300    0.2700
2.5000    0.3400
2.1000    0.5000
1.6700    0.4900
1.5000    0.6100
```

2.1.4 PCH3.DAT

This file contains data necessary for graphic output.

2.1.5 RESTART.DAT

Contains all the input data provided to the program by the user. Data in the file can be read, modified or new data added while the program is being run. Access to this file is direct; the record length is 80 bytes.

2.1.6 OUT.LST

This file contains data on the blast parameters and stope profile for use in developing loading instructions and identifying problem areas.

The following pages contains a worked-out example of the use of VCRM and the resulting OUT.LST file. The information provided by the user are represented by bold-faced characters.

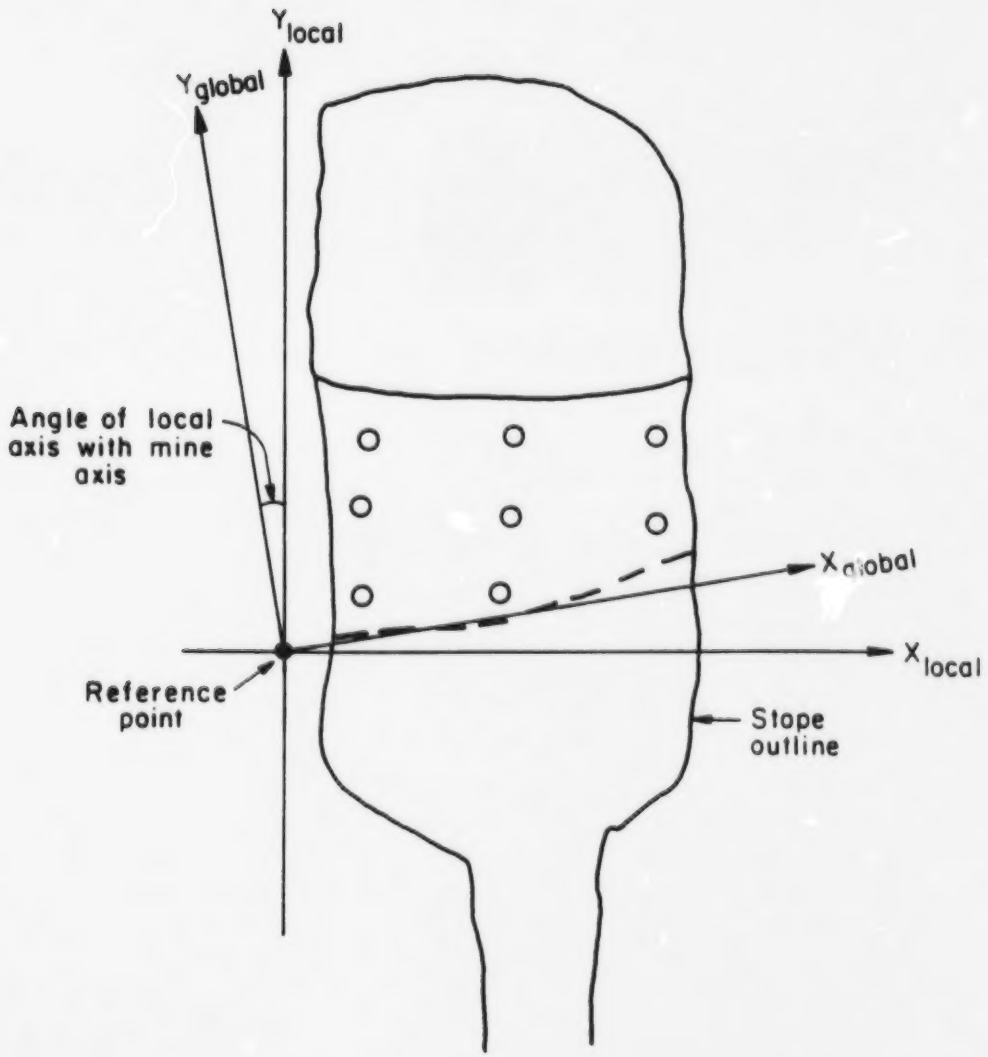


Figure 1: Reference point location

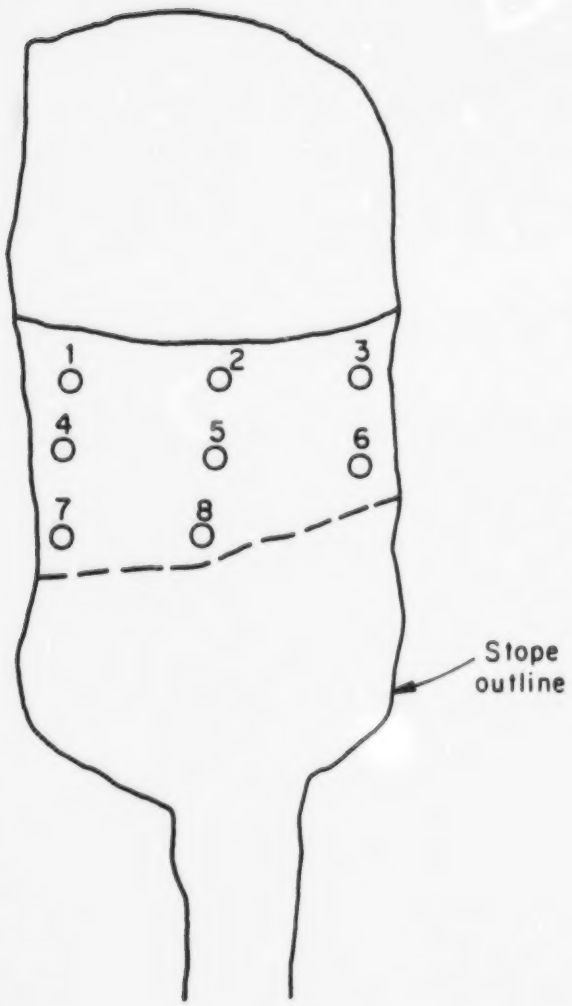


Figure 2: Numbering of holes

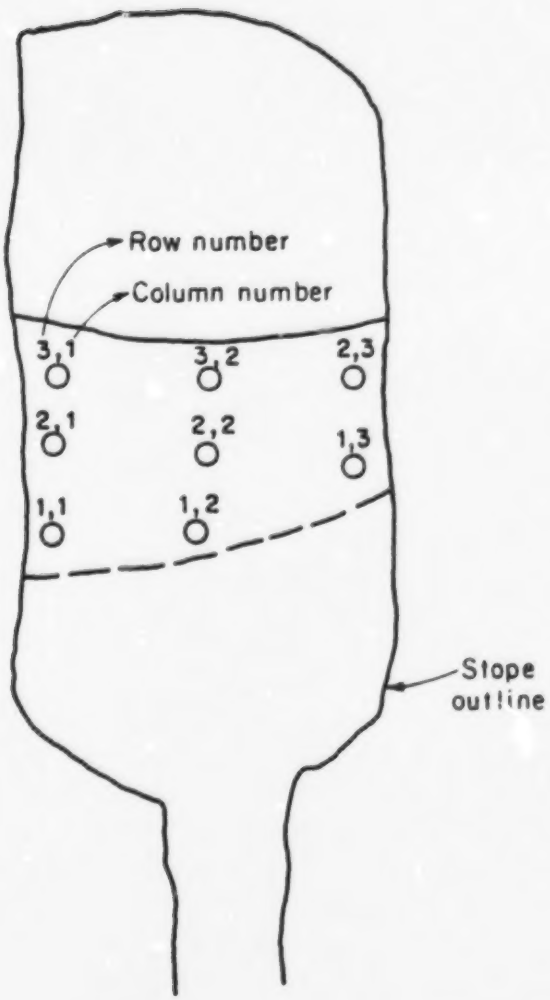


Figure 3: Hole row and column numbering

2.2 TEST EXAMPLE OF VCRM PROGRAM

RUN VCRM

```
*********************************************************
*                                                       *
*              P R O G R A M  V C R M                   *
*          TO DESIGN THE BLASTING IN AN                 *
*          UNDERGROUND STOPE USING THE                  *
*          VERTICAL CRATER RETREAT METHOD               *
*                                                       *
*********************************************************
```

by
Mining Resource Engineering Limited
and
Canadian Mining Technology Laboratory
Mining Research Laboratories
CANMET

```
Hit any key to continue

 Do you want to start from a restart file ? (y/n)
N
DO YOU WANT TO INPUT NEW CRATERING CURVES  ?
Y
        THE FOLLOWING DATA ARE RELATED TO THE CRATER TESTS
        -------------------------------------------------
 ENTER TYPE OF EXPLOSIVE USED FOR TESTS    :
SLURRY
ENTER DEPTH OF CONTAINED CHARGE (FT),
      WEIGHT OF EXPLOSIVE (LBS)    :
14     16
 WHAT IS THE WEIGHT STRENGTH OF THE EXPLOSIVE
 RELATIVE TO AN/FO   ?
1.3
 ENTER NUMBER OF POINTS TO DESIGN THE
      SCALED CRATER DEPTH - DEPTH RATIO
      CURVE    :
8
 ENTER SCALED DEPTH, DEPTH RATIO
      FOR EACH POINT OF THE CURVE    :
 POINT #  1 SC. DEPTH, DEPTH RATIO :
0.6    0.14
 POINT #  2 SC. DEPTH, DEPTH RATIO :
0.71    0.20
 POINT #  3 SC. DEPTH, DEPTH RATIO :
```

```
0.83    0.22
 POINT #  4 SC. DEPTH, DEPTH RATIO :

1.07    0.27
 POINT #  5 SC. DEPTH, DEPTH RATIO :

1.59    0.34
POINT #  6 SC. DEPTH, DEPTH RATIO :

0.87    0.50
 POINT #  7 SC. DEPTH, DEPTH RATIO :

0.52    0.49
 POINT #  8 SC. DEPTH, DEPTH RATIO :

0.36    0.61
 ENTER NUMBER OF POINTS TO DESIGN
       THE SCALED CRATER RADIUS - DEPTH RATIO
       CURVE  :

8
 ENTER SCALED CRATER RADIUS, DEPTH RATIO
       FOR EACH POINT OF THE CURVE  :
 POINT #  1 SC. RADIUS, DEPTH RATIO :

2.00    0.14
 POINT #  2 SC. RADIUS, DEPTH RATIO :

2.02    0.20
 POINT #  3 SC. RADIUS, DEPTH RATIO :

2.03    0.22
 POINT #  4 SC. RADIUS, DEPTH RATIO :

2.13    0.27
 POINT #  5 SC. RADIUS, DEPTH RATIO :

2.50    0.34
 POINT #  6 SC. RADIUS, DEPTH RATIO :

2.10    0.50
 POINT #  7 SC. RADIUS, DEPTH RATIO :

1.67    0.49
 POINT #  8 SC. RADIUS, DEPTH RATIO :

1.50    0.61
 ENTER 1 IF YOU WISH TO OPERATE AT THE OPTIMUM
 POINT ON THE CRATER CURVE
 OTHERWISE ENTER THE FRACTION OF THE
 OPTIMUM DEPTH RATIO (DELTA) AT WHICH
 YOU WISH TO OPERATE  ( EG. 0.75 )     :

0.83
         THE FOLLOWING DATA ARE RELATED TO YOUR BLASTING
         ----------------------------------------------
 ENTER THE DIAMETER OF THE BLASTHOLES (INCHES) :

6.5
 ENTER NUMBER OF HOLES IN THE BLAST  :
```

```
14
 ENTER THE ELEVATION OF THE FREE FACE OF THE BLAST  :

10600
 ENTER THE DENSITY OF THE ROCK (LBS/CU.FT)  :

200


                    D A T A  S U M M A R Y
                    ----------------------

 Borehole diameter                    :   6.5 inches
 Total number of holes                :    14
 Average elevation of the free face   : 10600.0 ft.
 Density of the rock                  :   200.0 lbs/cu.ft
 Is this correct ? (y/n)

Y
    THE FOLLOWING DATA ARE FOR CHECKING VIBRATION
    LEVELS AT PILLARS  AND OTHER PARTICULAR POINTS
    OF INTEREST ....


   ENTER THE NUMBER OF POINTS IN WHICH VIBRATIONS ARE
   TO BE CHECKED    :

2
   ENTER SPECIFIC POINTS IN WHICH VIBRATIONS WILL BE CHECKED.
  ( EACH POINT MUST BE SPECIFIED BY ITS COORDINATES SEPARATED
   BY COMMAS, AND THE MAXIMUM ACCEPTABLE LEVEL OF PEAK PARTICLE
    VELOCITY. E.G. 12.4,12.6,14.2,10.0)  :

20, 30, 20, 5.0
30, 30, 30, 5.0
 ENTER THE SITE FACTORS K, M FOR THE CALCULATION OF THE PEAK PARTICLE
            VELOCITY  :

57   -1.3


                    D A T A  S U M M A R Y
                    ----------------------

 Number of points for vibration checks :    2
                   Coordinates of points
                   ---------------------
 point #    1          X =                20.0
                       Y =                30.0
                       Z =                20.0
                       Acceptable PPV =       5.0 in./sec.
 point #    2          X =                30.0
                       Y =                30.0
                       Z =                30.0
                       Acceptable PPV =       5.0 in./sec.
 K factor :  57.000
 M factor :  -1.300
```

```
 Is this correct ? (y/n)

Y
 ENTER TYPE OF EXPLOSIVE TO BE USED IN THE BLAST  :

T-3
 WHAT IS THE WEIGHT STRENGTH RELATIVE TO ANFO
FOR THE EXPLOSIVE YOU ARE USING  ?

1.3
 WHAT IS THE DENSITY OF THE EXPLOSIVE YOU ARE USING ?
        (GM / CC.)

1.3
 ENTER THE LENGTH/DIAMETER RATIO FOR WHICH
 A CHARGE IS ASSUMED TO ACT AS A SHERICAL
 CHARGE : ( TYPICAL : 6.0 to 8.0 )

7.0
 ENTER STOPE LENGTH, STOPE WIDTH AND STOPE DEPTH  (FT) :

100.0    100.0    100.0

                    D A T A  S U M M A R Y
                    ----------------------

 Explosive for the blast          :T-3
 Weight strength of the explosive
          relative to ANFO        :  1.30
 Density of the explosive         :  1.30 g/cc
 Ratio length/dia. for sherical
 action of the charge             :  7.00
 Stope length                     :100.00 ft.
 Stope width                      :100.00 ft.
 Stope depth                      :100.00 ft.
 Is this correct ? (y/n)

Y
 ENTER {M} FOR MANUAL OR {A} FOR AUTOMATIC
       GENERATION OF THE INITIATION SEQUENCE    :

A


            AUTOMATIC GENERATION OF SEQUENCE
            --------------------------------


 ENTER THE NUMBER OF THE HOLE WHICH DETONATES FIRST :

3
                    HOLE NUMBER          INITIATION PERIOD
                    -----------          -----------------
```

```
                                1           3
                                2           2
                                3           1
                                4           2
                                5           4
                                6           2
                                7           3
                                8           6
                                9           6
                               10           8
                               11           7
                               12           9
                               13           9
                               14           5
 Is this correct ? (y/n)
Y

                    E X E C U T I O N  IN  P R O G R E S S

                          P l e a s e  w a i t

           3
           2
           4
           6
           1
           7
           5
          14
           8
           9
          11
          10
          12
          13
FORTRAN STOP
$
```

2.3 LISTING OF RESULTS AS STORED IN OUT.LST

P R O G R A M V C R M

W R I T T E N F O R T H E D E S I G N O F T H E
B L A S T I N A N U N D E R G R O U N D S T O P E
U S I N G T H E V E R T I C A L C R A T E R
R E T R E A T M E T H O D .

YOUR STOPE SAMPLE PROBLEM

EXPLOSIVE USED :T-3
DENSITY :0.0470 LBS/CUB. INCH
DIAMETER :6.5000 INCHES

MODIFIED INITIATION SEQUENCE

HOLE NUMBER	DELAY PERIOD
1	3
2	2
3	1
4	2
5	4
6	2
7	3
8	6
9	6
10	8
11	7
12	9
13	9
14	5

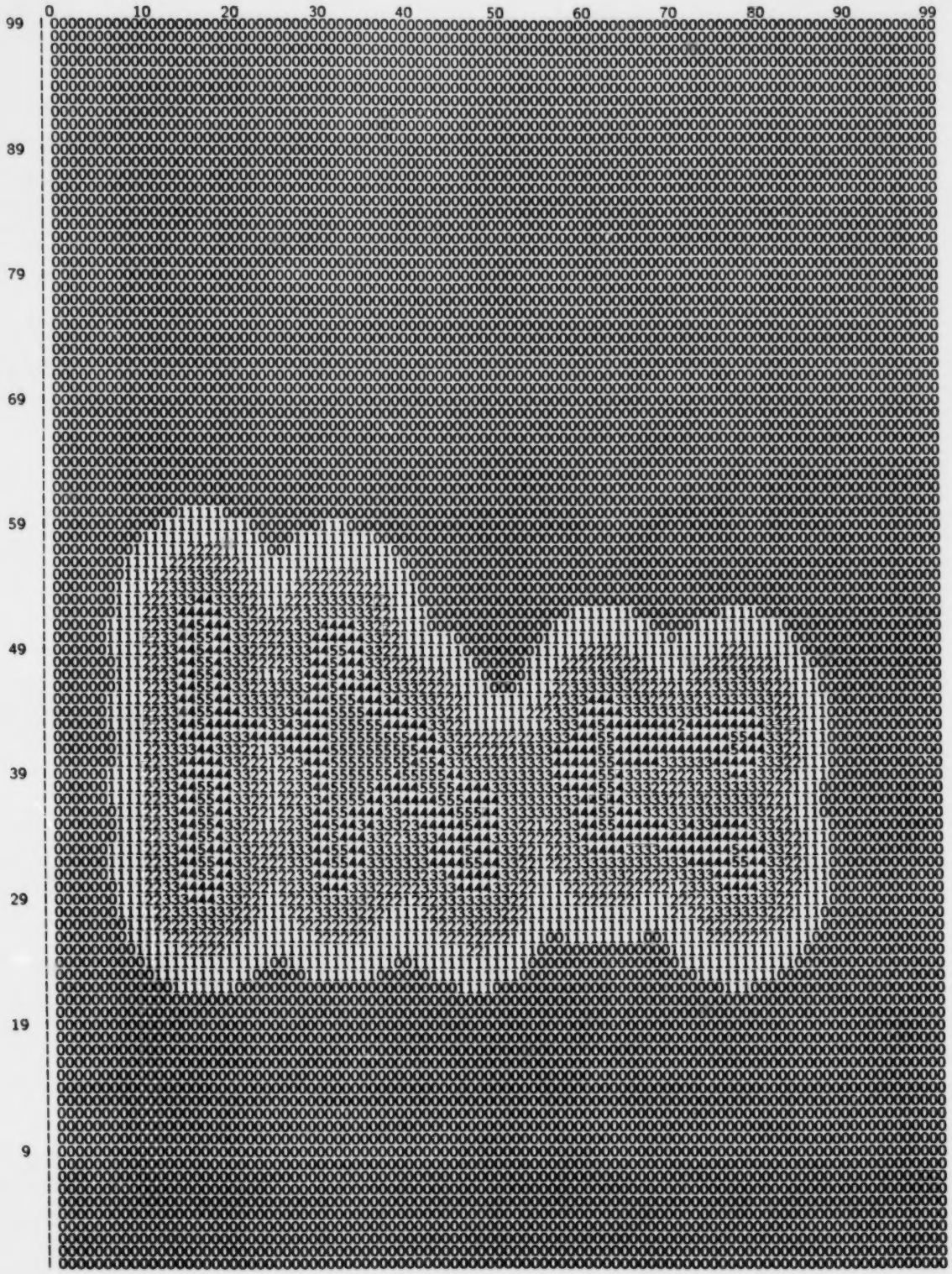
WEIGHT OF CHARGES IN THE BLAST

HOLE NUMBER	WEIGHT (LBS)
1	71.
2	71.
3	71.
4	71.
5	71.
6	71.
7	71.
8	71.
9	71.
10	71.
11	71.
12	71.
13	71.
14	71.

PLAN VIEW OF THE BLAST

ELEVATIONS REPRESENTED BY THE NUMBERS OF THE PRINTOUT

NUMBER 0	55.0	FT
NUMBER 1	53.7	FT
NUMBER 2	52.4	FT
NUMBER 3	51.1	FT
NUMBER 4	49.8	FT
NUMBER 5	48.5	FT


0
10
20
30
40
50
60
70
80
90
99
89
79
69
59
49
39
29
19
9

SUMMARY

TOTAL WEIGHT OF EXPLOSIVE : 993. LBS

ESTIMATED TONNAGE BROKEN : 781. TONS

DELAY NUMBER	QUANTITY
1	1
2	3
3	2
4	1
5	1
6	2
7	1
8	1
9	2

INSTRUCTIONS FOR LOADING

HOLE NUMBER	CHARGE LOCATION	CHARGE WEIGHT	DELAY NUMBER
1	51.	71.	3
2	51.	71.	2
3	50.	71.	1
4	50.	71.	2
5	51.	71.	4
6	51.	71.	2
7	50.	71.	3
8	51.	71.	6
9	50.	71.	6
10	51.	71.	8
11	51.	71.	7
12	51.	71.	9
13	50.	71.	9
14	50.	71.	5

3. LDBB PROGRAM

3.1 DATA FILES FOR LDBB PROGRAM

All data files are free formatted: a blank character is required between each value.

Before running the LDBB program, the following files must be created:

3.1.1 YOURBENC.DAT

Information on the stope.

Line 1: Title (up to 80 characters)

Line 2: X, Y, Z coordinates of reference point. It is required for the conversion of global to local coordinates. The reference point should be located close to the blast and in such a way that the local X, Y coordinates of the blastholes are positive (figure 1).

Line 3: Stope length, width and depth (ft.). These data are used in the PGRAPH program and indicate the dimensions of the windows on which the plan views and cross-sections will be drawn.

Line 4: Angle (degrees, counter clockwise) of local axis X_l with mine axis X_g. (see Fig 1)

Example:

```
SAMPLE STOPE FROM FALCONBRIDGE
  10000.0    1622.0    10210.5
     36.0      50.0      107.0
     00.0
```

3.1.2 YOUR2.DAT

Coordinates of the holes at different elevations.

Line 1: The following information on first hole:

Hole number: The actual number of the hole . The sequence is not important. (see Figure 2)

Number of points: Number of points along the axis of the hole where coordinates were measured.

Row number: Number of the group of holes which are going to be projected to the ZX plane when using the graphics program. (see Fig. 3)

Column number: Number of the group of holes which will be projected to the ZY plane when using the graphics program. (see Fig. 3)

Hole diameter: Diameter of the hole in inches.

Line 2: X,Y,Z coordinates of point 1. first hole.
Line 3: X,Y,Z coordinates of point 2. first hole.
Line N+1: X,Y,Z coordinates of point N. first hole.

The Z coordinate increases with depth.

Enter all holes in same manner.

Example:

```
   1    2     1    1       6.50
 10027.00   1634.50  10210.50
 10023.50   1633.50  10317.00
   2    2     2    1       6.50
 10027.50   1643.00  10210.50
 10024.00   1644.00  10317.00
   3    2     3    1       6.50
 10026.50   1657.50  10210.50
 10026.50   1656.50  10317.00
   4    2     4    1       6.50
 10030.50   1664.50  10210.50
 10036.50   1664.00  10317.00
```

3.1.3 TOP.DAT

Data related to the points beyond which backbreak should be avoided.

First line: number of points

Subsequent lines: X, Y coordinates of each point.

Example:

```
   4
 10010.     1634.
 10010.     1643.
 10010.     1657.
 10020.     1664.
```

3.1.4 BBLAST.DAT

Data providing the free face of the blast.

This file is very similar to YOUR2.DAT. However, instead of the coordinates along the axis of the borehole, coordinates along lines on the free face of the blast are provided. The lines should be provided counter clockwise and they should result in the outline of the slot opening (Figure 4).

A maximum of 10 lines can be given. The data are provided as follows:

Line 2: X,Y,Z coordinates of point 1. first line.
Line 3: X,Y,Z coordinates of point 2. first line.
Line N+1: X,Y,Z coordinates of point N. first line.

The Z coordinate increases with depth.

Enter all lines in same manner.

Example:

```
  1    2
10037.00   1634.50  10210.50
10033.50   1633.50  10317.00
  2    2
10037.50   1643.00  10210.50
10034.00   1644.00  10317.00
  3    2
10036.50   1657.50  10210.50
10036.50   1656.50  10317.00
  4    2
10030.50   1664.50  10210.50
10036.50   1664.00  10317.00
  5    2
10047.00   1664.50  10210.50
10043.50   1664.00  10317.00
  6    2
10046.50   1657.50  10210.50
10046.50   1656.50  10317.00
  7    2
10047.50   1643.00  10210.50
10044.00   1644.00  10317.00
  8    2
10047.00   1634.50  10210.50
10033.50   1633.50  10317.00
```

The following files must be opened before executing the program:

3.1.5 BCURV.DAT

Definition of the cratering curves. This file can be created before running the main program or interactively while using it.

Example:

```
8                          <-- Number of points for the Scaled crater depth VS depth ratio curve
                                                                for spherical charge
0.6000    0.1400
0.7100    0.2000
0.8300    0.2200
1.0700    0.2700
1.5900    0.3400
0.8700    0.5000
0.5200    0.4900
0.3600    0.6100
```

```
8                    <-- Number of points for the Scaled crater radius VS depth ratio curve
2.0000    0.1400         for spherical charge
2.0200    0.2000
2.0300    0.2200
2.1300    0.2700
2.5000    0.3400
2.1000    0.5000
1.6700    0.4900
1.5000    0.6100
8                    <-- Number of points for the Scaled crater depth VS depth ratio curve
0.6000    0.1400         for cylindrical charge
0.7100    0.2000
0.8300    0.2200
1.0700    0.2700
1.5900    0.3400
0.8700    0.5000
0.5200    0.4900
0.3600    0.6100
8                    <-- Number of points for the Scaled crater radius VS depth ratio curve
2.0000    0.1400         for cylindrical charge
2.0200    0.2000
2.0300    0.2200
2.1300    0.2700
2.5000    0.3400
2.1000    0.5000
1.6700    0.4900
1.5000    0.6100
```

3.1.6 PCH3B.DAT

This file contains data necessary for the graphic output.

3.1.7 RESTART.DAT

Contains all the input data provided to the program by the user. When run, the program offers the possibility of reading data previously stored in this file, making modifications to data or providing new data. The access to this file is direct and record length is 80 bytes.

3.1.8 DECKS.DAT

This file stores and reads data computed in LDBB. The file is an unformatted, direct access of record length 80 bytes.

3.1.9 BBOUT.LST

This file contains data on the blast and an after blast profile of the stope in order to indicate problem areas and loading instructions.

The following pages contain a worked-out example of the LDBB program and the listing of the resulting BBOUT.LST file. The answers provided by the user are represented by bold-faced characters.

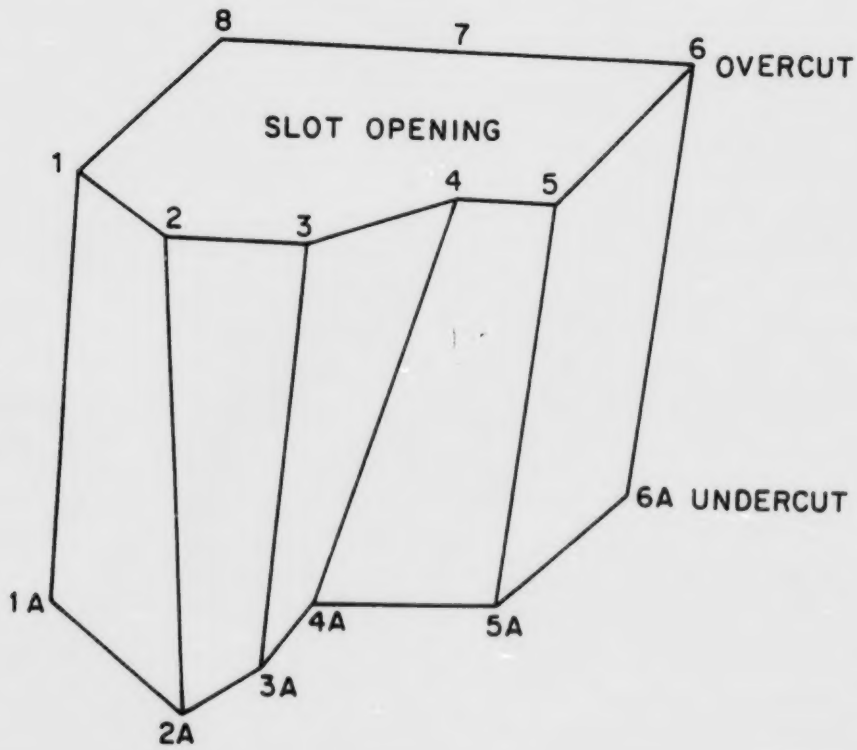


Figure 4: Slot outline (BBLAST.DAT)

3.2 TEST EXAMPLE OF LDBB PROGRAM

RUN LDBB

```
**********************************************************
*                                                        *
*                P R O G R A M  L D B B                  *
*           TO SIMULATE THE BLASTING IN AN               *
*           UNDERGROUND LARGE DIAMETER BLASTHOLE         *
*           BENCH.                                       *
*                                                        *
**********************************************************
```

by
Mining Resource Engineering Limited
and
Canadian Mining Technology Laboratory
Mining Research Laboratories
CANMET

```
Hit any key to continue

 Do you want to start from a restart file ? (y/n)
N
        THE FOLLOWING DATA ARE RELATED TO THE CRATER TESTS
        --------------------------------------------------
 ENTER DEPTH OF CONTAINED CHARGE ( FT ),
       WEIGHT OF EXPLOSIVE ( LBS)
       FOR SPHERICAL CHARGES  :
           ---------

14    16
 ENTER DEPTH OF CONTAINED CHARGE ( FT ),
       WEIGHT OF EXPLOSIVE ( LBS)
 FOR CYLINDRICAL CHARGES  :
     -----------

14    18
 WHAT IS THE WEIGHT STRENGTH OF THE EXPLOSIVE
 RELATIVE TO AN/FO ?

1.3
 DO YOU WANT TO INPUT NEW CRATERING CURVES  ? (Y/N)
N
```

```
 ENTER 1 IF YOU WISH TO OPERATE AT THE OPTIMUM
 POINT ON THE CRATER CURVE
 OTHERWISE ENTER THE FRACTION OF THE
 OPTIMUM DEPTH RATIO (DELTA) AT WHICH
 YOU WISH TO OPERATE  (EG. 0.75)   :

0.75
         THE FOLLOWING DATA ARE RELATED TO YOUR BLASTING
         -----------------------------------------------
 ENTER THE DIAMETER OF THE BLASTHOLES (INCHES)   :

6.5
 ENTER NUMBER OF HOLES IN THE BLAST   :

4
 ARE THE HOLES BREAKTHROUGH HOLES ? (Y/N)

Y


                    D A T A   S U M M A R Y
                    -----------------------

 Borehole Diameter      :   6.5 inches.
 Total number of holes :     4

 The holes are breakthrough.
 Is this correct ? (y/n)

Y
    THE FOLLOWING DATA ARE FOR CHECKING VIBRATION
    LEVELS AT PILLARS  AND OTHER PARTICULAR POINTS
    OF INTEREST ....


   ENTER THE NUMBER OF POINTS IN WHICH VIBRATIONS ARE
   TO BE CHECKED   :

0


                    D A T A   S U M M A R Y
                    -----------------------

 Number of points for vibration checks :    0
 Is this correct ? (y/n)

Y
 ENTER NUMBER OF EXPLOSIVES AVAILABLE FOR THE BLAST   :

2
 ENTER NAME OF EXPLOSIVE   :
SLURRY
   ENTER WEIGHT STRENGTH OF THE EXPLOSIVE RELATIVE TO
```

```
     ANFO   :

1.25
ENTER DENSITY OF THE EXPLOSIVE :
  ( GM/CC )


1.25
 ENTER NAME OF EXPLOSIVE   :

EMULSION
  ENTER WEIGHT STRENGTH OF THE EXPLOSIVE RELATIVE TO
     ANFO   :

1.3
ENTER DENSITY OF THE EXPLOSIVE :
  ( GM/CC )

1.3
 ENTER NAME OF MAIN EXPLOSIVE TO BE USED   :

EMULSION

                    D A T A   S U M M A R Y
                    -----------------------

 Number of explosives:    2
 Name of explosive      weight strength    density
                        relative to ANFO    (g/cc)
 ------------------------------------------------
   SLURRY                  1.25             1.25
   EMULSION                1.30             1.30
  Name of the main explosive:EMULSION
 Is this correct ? (y/n)

Y
 ENTER THE MAX DIMENSION OF THE PART OF
 THE STOPE WHICH WILL BE BLASTED (FEET) :

100
 ENTER DEPTH OF THE HOLES  (FT) :

100
 ENTER THE ROCK DENSITY (LBS/CU. FT) :

200
       KUZ - RAM  MODEL

 ENTER THE ROCK FACTOR FOR FRAGMENTATION
 CALCULATIONS ( 1 TO 15 ) :

12
 ENTER THE STANDARD DEVIATION FOR DRILLING ACCURACY
  ( FT )     :
```

```
0.7
 ENTER POWDER FACTOR FOR THE BLAST (LBS/CU.FT) :

0.11
 ENTER BURDEN AND SPACING OF THE PATTERN  (FT) :

10    10
 ENTER MAXIMUM DEPTH RATIO FOR ACCEPTABLE FRAGMENTATION :
  TYPICAL VALUES :
   HARD ROCK : 0.75
   SOFT ROCK : 0.85

0.80
 The minimum separation distance in order to
 avoid cross propagation is :       8.1 ft.
 The maximum separation distance in order to
 have sufficient fragmentation between decks
 is :      17.1 ft.
 The number of decks per hole according to the
 data you have provided and the calculation of
 a suggested separation distance between decks
 is  :   4
 The weight of explosive per deck is :  275.1lbs.
 These data can be modified in the following.


 ENTER NUMBER OF DECKS PER BOREHOLE  :

4
 ENTER DATA RELATED TO THE EXPLOSIVE DECKS :
 ------------------------------------------


 Enter distance from the bottom of the hole to the
 bottom of the first charge (for each hole separately) :

hole #  1 :

8.1
hole #  2 :

8.1
hole #  3 :

8.1
hole #  4 :

8.1
 ENTER WEIGHT PER DECK FOR EACH HOLE AT LEVEL #  1
hole #  1 :

275
hole #  2 :

275
hole #  3 :
```

```
275
hole #  4 :

275
 ENTER EXPLOSIVE TYPE PER DECK FOR EACH HOLE AT
 LEVEL  #  1
hole #  1 :

EMULSION
hole #  2 :

EMULSION
hole #  3 :

SLURRY
hole #  4 :

EMULSION
 ENTER INITIATION SEQUENCE FOR EACH HOLE AT LEVEL #  1
hole #  1 :

2
hole #  2 :

1
hole #  3 :

3
hole #  4 :

4
The suggested separation distance between charges
in the same borehole is :      8.24ft
Enter separation distance in each hole between
level of decks #  2 and the previous one :
hole #  1 :

8.24
hole #  2 :

8.24
hole #  3 :

8.24
hole #  4 :
.
.
.
.
.
.
.

 SUMMARY OF DATA
 ---------------
```

```
 number of decks per hole :      4
Is this correct ? (y/n)
```

Y

```
 Distance from bottom of the hole  to the bottom of the first deck
  hole number                  distance (ft)
  -----------                  -------------
          1                        8.
          2                        8.
          3                        8.
          4                        8.
  Is this correct (y/n)
```

Y

```
 Weight of explosive decks in level #     1
 hole number               weight (lbs)
 -----------               ------------
         1                     275.
         2                     275.
         3                     275.
         4                     275.
 Is this correct? (y/n)
```

Y

```
  Explosive type in level #     1
  hole number             explosive type
  -----------             --------------
         1                    EMULSION
         2                    EMULSION
         3                    SLURRY
         4                    EMULSION
 Is this correct? (y/n)
```

Y

```
 Initiation sequence for level #     1
 hole number                  sequence
 -----------                  --------
         1                        2
         2                        1
         3                        3
         4                        4
 Is this correct? (y/n)
```

Y

```
 Distance between charges in level #      1
 and charges in level #      2
 hole number                  distance (ft)
 -----------                  -------------
         1                        8.
         2                        8.
         3                        8.
         4                        8.
  Is this correct (y/n)
```

```
Y
.
.
.
.
.
.

                    EXECUTION  IN  PROGRESS

                    p l e a s e    w a i t
The explosive in hole  2 level #  1
cannot optimize output.
Change it with an explosive having a bulk
strength of 2.90 relative to the previous one.

The explosive in hole  1 level #  1
cannot optimize output.
Change it with an explosive having a bulk
strength of 2.04 relative to the previous one.

The explosive in hole  3 level #  1
cannot optimize output.
Change it with an explosive having a bulk
strength of 3.00 relative to the previous one.

The explosive in hole  2 level #  2
cannot optimize output.
Change it with an explosive having a bulk
strength of 3.23 relative to the previous one.

The explosive in hole  1 level #  2
cannot optimize output.
Change it with an explosive having a bulk
strength of 1.96 relative to the previous one.

The explosive in hole  3 level #  2
cannot optimize output.
Change it with an explosive having a bulk
strength of 3.00 relative to the previous one.

The explosive in hole  2 level #  3
cannot optimize output.
Change it with an explosive having a bulk
strength of 3.02 relative to the previous one.

The explosive in hole  1 level #  3
cannot optimize output.
Change it with an explosive having a bulk
strength of 1.91 relative to the previous one.

The explosive in hole  3 level #  3
cannot optimize output.
```

```
 Change it with an explosive having a bulk
 strength of 2.89 relative to the previous one.

 The explosive in hole  2 level #  4
 cannot optimize output.
 Change it with an explosive having a bulk
 strength of 2.92 relative to the previous one.

 The explosive in hole  1 level #  4
 cannot optimize output.
 Change it with an explosive having a bulk
 strength of 1.85 relative to the previous one.

 The explosive in hole  3 level #  4
 cannot optimize output.
 Change it with an explosive having a bulk
 strength of 3.00 relative to the previous one.

 The explosive in hole  4 level #  4
 cannot optimize output.
 Change it with an explosive having a bulk
 strength of 1.34 relative to the previous one.

 The last explosive deck in hole #   4
 will break the rock beyond the specified
 points for maximum acceptable backbreak
 Recommended steming :   3.6 ft.
FORTRAN STOP
$
```

3.3 LISTING OF RESULTS AS STORED IN BBOUT.LST

P R O G R A M L D B B

W R I T T E N F O R T H E D E S I G N O F T H E
B L A S T I N A N U N D E R G R O U N D S T O P E
U S I N G T H E L A R G E D I A M E T E R
B L A S T H O L E B E N C H I N G M E T H O D

SAMPLE STOPE

The minimum separation distance in order to avoid cross propagation is : 8.1 ft.
The maximum separation distance in order to have sufficient fragmentation between decks is : 17.1 ft.
The explosive in hole 2 level # 1 cannot optimize output.
Change it with an explosive having a bulk strength of 2.90 relative to the previous one.

The explosive in hole 1 level # 1 cannot optimize output.
Change it with an explosive having a bulk strength of 2.04 relative to the previous one.

The explosive in hole 3 level # 1 cannot optimize output.
Change it with an explosive having a bulk strength of 3.00 relative to the previous one.

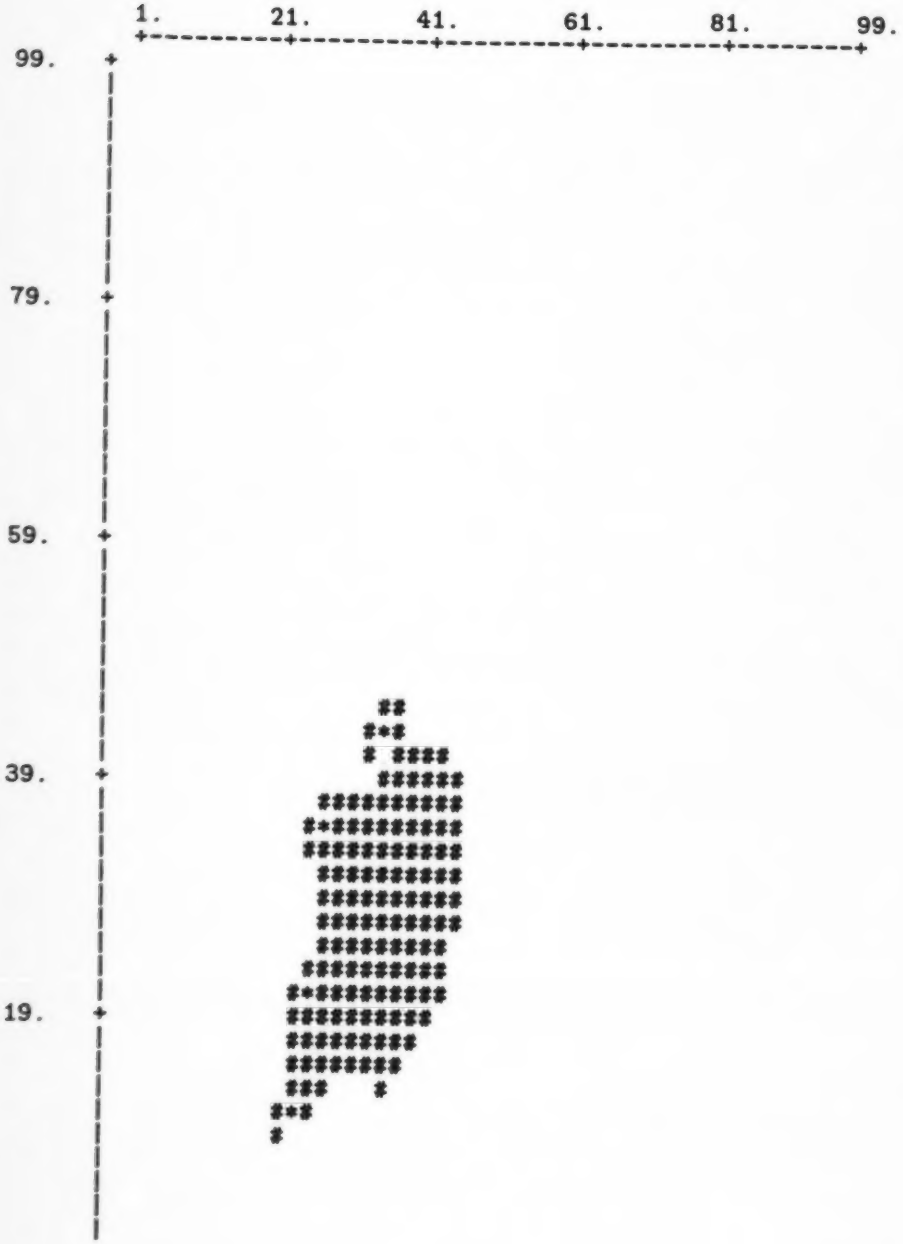
INITIATION SEQUENCE IN LEVEL # 1

HOLE NUMBER	DELAY PERIOD
1	2
2	1
3	3
4	4

WEIGHT OF EXPLOSIVE DECKS IN LEVEL # 1

HOLE NUMBER	WEIGHT (LBS)	EXPLOSIVE TYPE
1	275.	EMULSION
2	275.	EMULSION
3	275.	SLURRY
4	275.	EMULSION

PLAN VIEW AT DEPTH 91.9047



The explosive in hole 2 level # 2
cannot optimize output.
Change it with an explosive having a bulk
strength of 3.23 relative to the previous one.

The explosive in hole 1 level # 2
cannot optimize output.
Change it with an explosive having a bulk
strength of 1.96 relative to the previous one.

The explosive in hole 3 level # 2
cannot optimize output.
Change it with an explosive having a bulk
strength of 3.00 relative to the previous one.

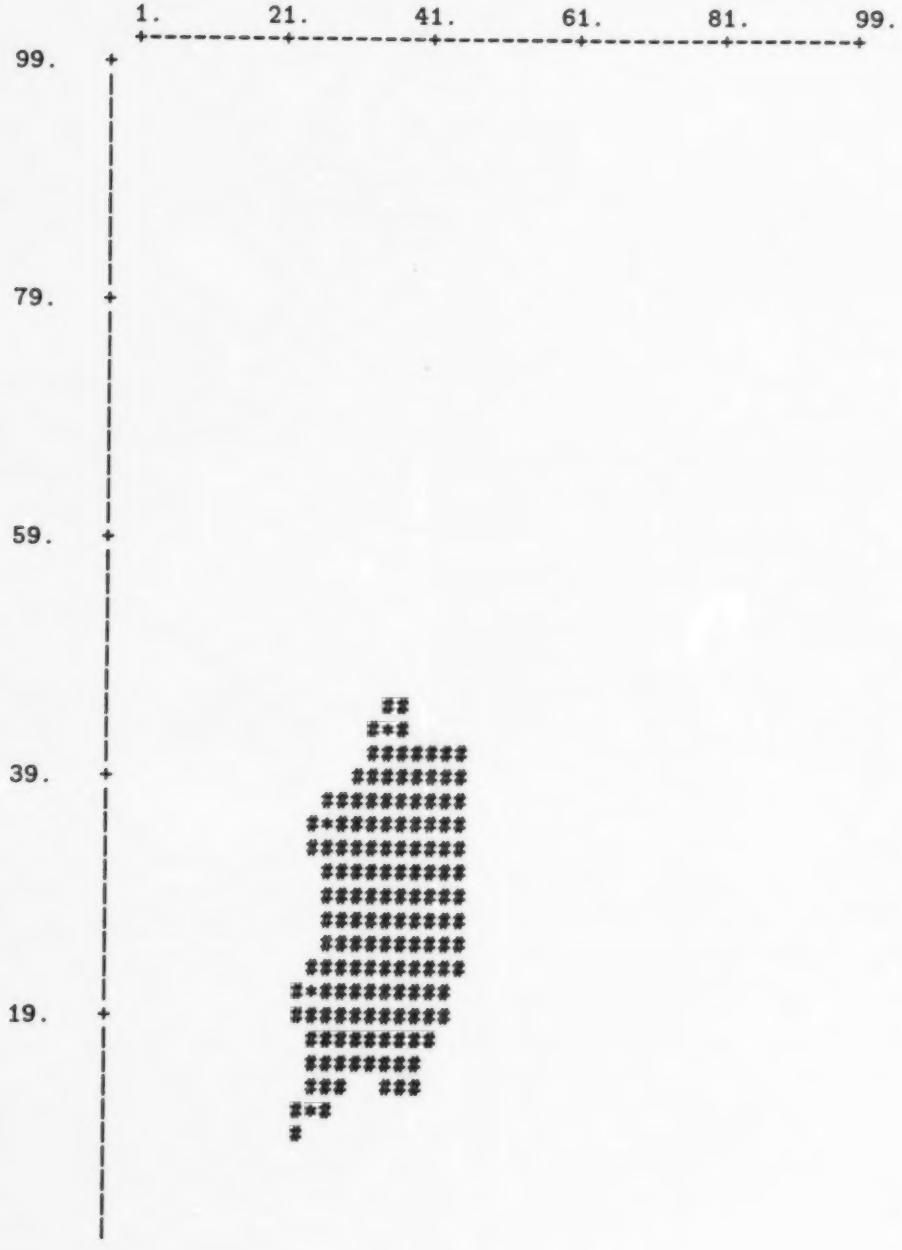
INITIATION SEQUENCE IN LEVEL # 2

HOLE NUMBER	DELAY PERIOD
1	3
2	2
3	4
4	5

WEIGHT OF EXPLOSIVE DECKS IN LEVEL # 2

HOLE NUMBER	WEIGHT (LBS)	EXPLOSIVE TYPE
1	275.	EMULSION
2	275.	EMULSION
3	275.	SLURRY
4	275.	EMULSION

PLAN VIEW AT DEPTH 68.9745



The explosive in hole 2 level # 3
cannot optimize output.
Change it with an explosive having a bulk
strength of 3.02 relative to the previous one.

The explosive in hole 1 level # 3
cannot optimize output.
Change it with an explosive having a bulk
strength of 1.91 relative to the previous one.

The explosive in hole 3 level # 3
cannot optimize output.
Change it with an explosive having a bulk
strength of 2.89 relative to the previous one.

1

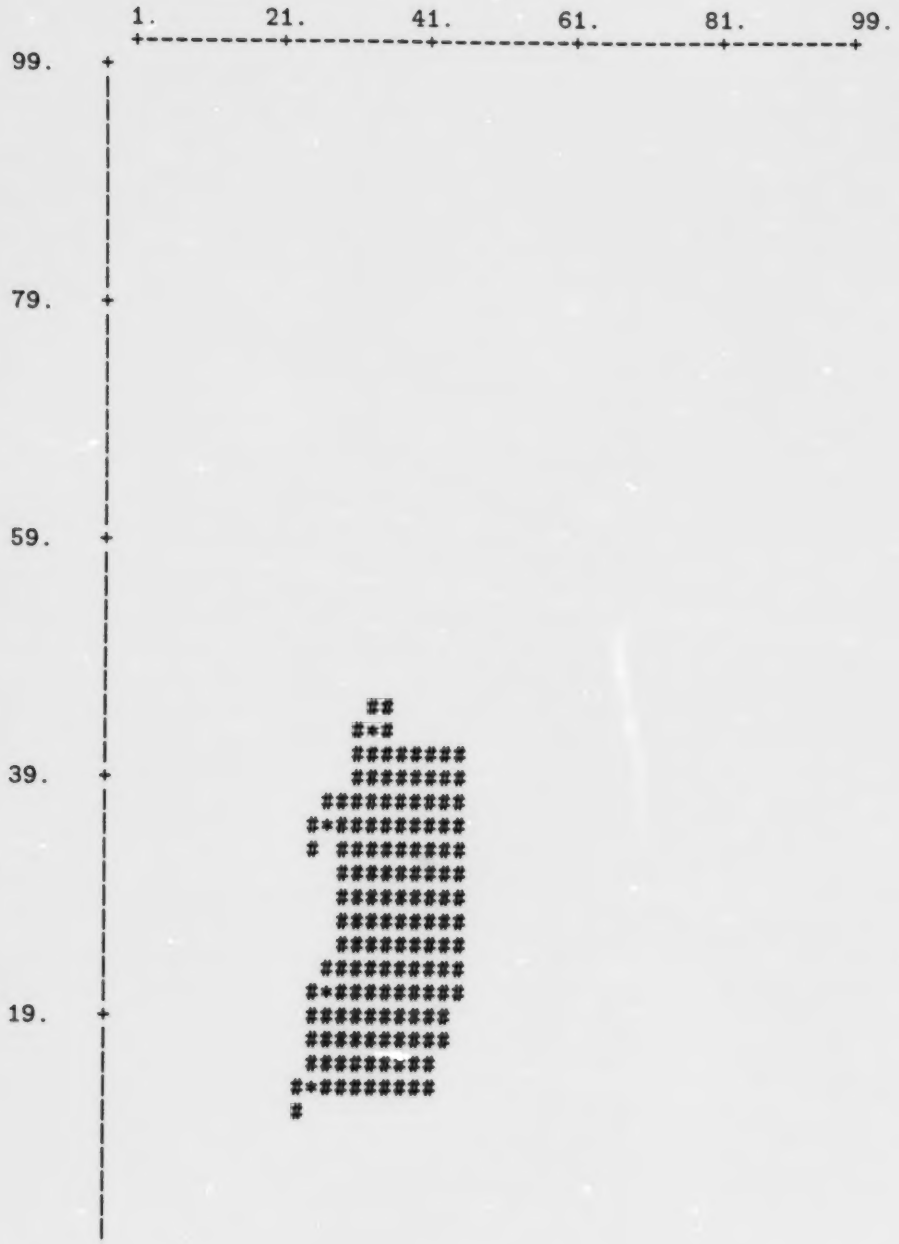
INITIATION SEQUENCE IN LEVEL # 3

HOLE NUMBER	DELAY PERIOD
1	4
2	3
3	5
4	6

WEIGHT OF EXPLOSIVE DECKS IN LEVEL # 3

HOLE NUMBER	WEIGHT (LBS)	EXPLOSIVE TYPE
1	270.	EMULSION
2	270.	EMULSION
3	270.	EMULSION
4	270.	EMULSION

PLAN VIEW AT DEPTH 46.0443



The explosive in hole 2 level # 4
cannot optimize output.
Change it with an explosive having a bulk
strength of 2.92 relative to the previous one.

The explosive in hole 1 level # 4
cannot optimize output.
Change it with an explosive having a bulk
strength of 1.85 relative to the previous one.

The explosive in hole 3 level # 4
cannot optimize output.
Change it with an explosive having a bulk
strength of 3.00 relative to the previous one.

The explosive in hole 4 level # 4
cannot optimize output.
Change it with an explosive having a bulk
strength of 1.34 relative to the previous one.

The last explosive deck in hole # 4
will break the rock beyond the specified
points for maximum acceptable backbreak
Recommended steming : 3.6 ft.

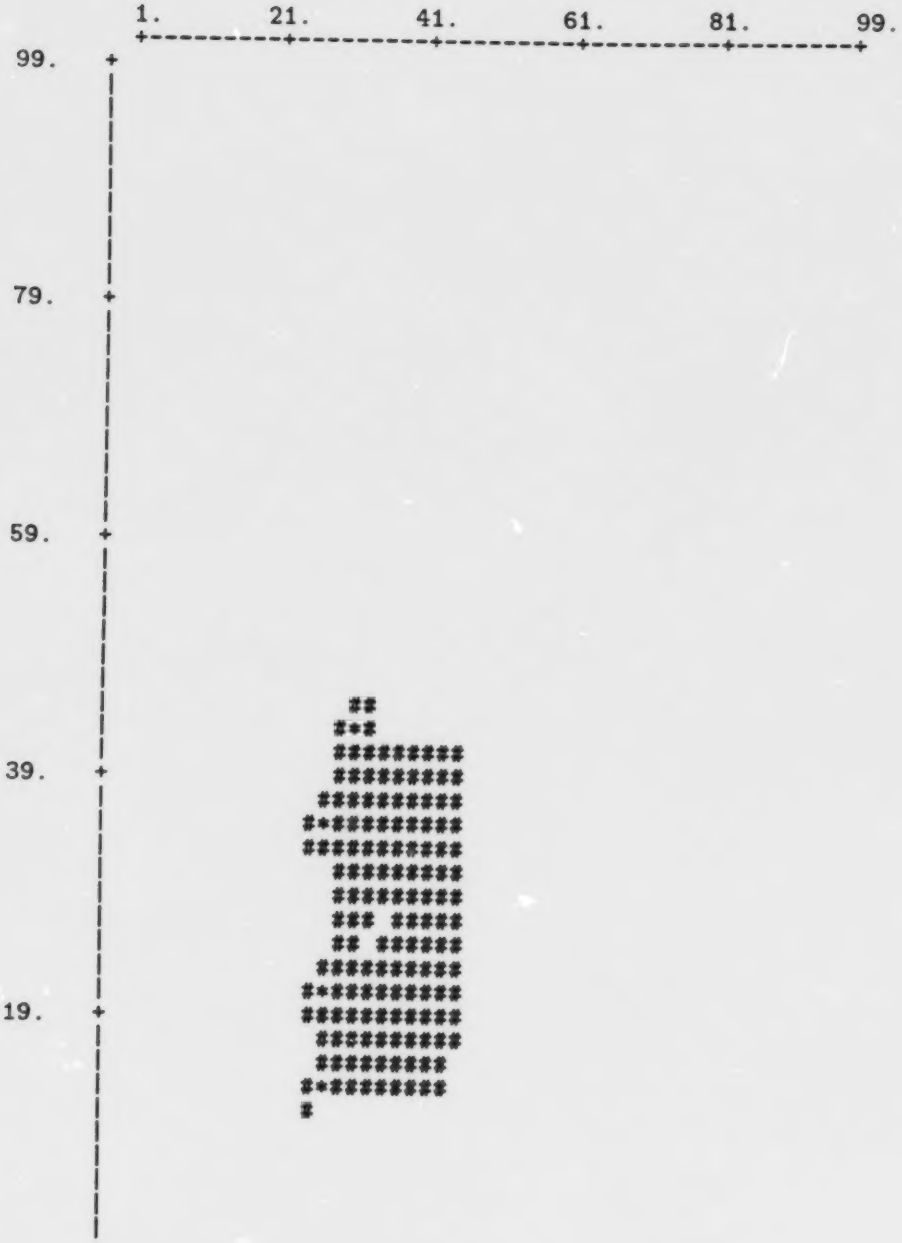
INITIATION SEQUENCE IN LEVEL # 4

HOLE NUMBER	DELAY PERIOD
1	6
2	5
3	7
4	8

WEIGHT OF EXPLOSIVE DECKS IN LEVEL # 4

HOLE NUMBER	WEIGHT (LBS)	EXPLOSIVE TYPE
1	280.	EMULSION
2	280.	SLURRY
3	280.	SLURRY
4	280.	SLURRY

PLAN VIEW AT DEPTH 23.3812



SUMMARY

TOTAL WEIGHT OF EXPLOSIVE : 4400. LBS

DELAY NUMBER	QUANTITY
1	1
2	2
3	3
4	3
5	3
6	2
7	1
8	1

INSTRUCTIONS FOR LOADING

HOLE NUMBER	CHARGE LOCATION	CHARGE WEIGHT	DELAY NUMBER	EXPLOSIVE TYPE
1	92.	275.	2	EMULSION
	69.	275.	3	EMULSION
	46.	270.	4	EMULSION
	23.	280.	6	EMULSION
2	92.	275.	1	EMULSION
	69.	275.	2	EMULSION
	46.	270.	3	EMULSION
	23.	280.	5	SLURRY
3	92.	275.	3	SLURRY
	68.	275.	4	SLURRY
	45.	270.	5	EMULSION
	22.	280.	7	SLURRY
4	92.	275.	4	EMULSION
	69.	275.	5	EMULSION
	46.	270.	6	EMULSION
	24.	280.	8	SLURRY

PREDICTED FRAGMENTATION

31.50	PERCENT PASSING SIZE =	53.09 INCHES
27.56	PERCENT PASSING SIZE =	38.17 INCHES
23.62	PERCENT PASSING SIZE =	27.98 INCHES
19.69	PERCENT PASSING SIZE =	20.37 INCHES
15.75	PERCENT PASSING SIZE =	14.40 INCHES
11.81	PERCENT PASSING SIZE =	9.57 INCHES
7.87	PERCENT PASSING SIZE =	5.62 INCHES

4. PGRAPH PROGRAM

PGRAPH is a program which produces graphics output of horizontal and vertical projections of the loaded or empty blastholes.

Due to copyright regulations, it is impossible to provide the executable version of this program. Therefore, the user must compile the program's source codes in order to execute it.

The files PANG, PCROSN, PGRAPH, PLAN and PTRANS are compiled using a fortran compiler. The five created object files are then linked with the GKS object library.

As previously mentioned, the use of this program is constrained to a system having the proper hardware.

The following files are required to run PGRAPH:

1. If results for a VCR stope are required:
   (a) YOURSTOP.DAT
   (b) YOUR.DAT
   (c) PCH3.DAT
2. If results for a large diameter blasthole bench are required:
   (a) YOURBENC.DAT
   (b) YOUR2.DAT
   (c) PCH3B.DAT

The files YOURSTOP.DAT, YOUR.DAT, YOURBENC.DAT and YOUR2.DAT are the same files which were created for the VCRM or the LDBB programs. The files PCH3.DAT and PCH3B.DAT are produced by the VCRM and LDBB programs respectively.

PGRAPH runs interactively. It is recommended that the necessary graphics device drivers are installed before running the program. It is also recommended that a high resolution display is used when output on the screen is required.

The following is an example of the PCH3.DAT file.

```
1    1    1
     -49.05    -45.26    49.58    45.79    73.64    6.50    0    3
     1    2    1
     -49.05    -45.26    49.31    45.52    73.64    6.50    0    2
     1    3    1
     -49.05    -45.26    49.09    45.30    73.64    6.50    0    1
     1    4    1
     -49.05    -45.26    49.05    45.26    73.64    6.50    0    2
     1    1    2
     -49.05    -45.26    49.63    45.84    73.64    6.50    0    4
     1    2    2
     -49.05    -45.26    49.22    45.43    73.64    6.50    0    2
     1    3    2
     -49.05    -45.26    49.05    45.26    73.64    6.50    0    3
     1    1    3
     -49.05    -45.26    49.69    45.90    73.64    6.50    0    5
     1    2    3
     -49.05    -45.26    49.05    45.26    73.64    6.50    0    5
     1    1    4
     -49.05    -45.26    49.76    45.97    73.64    6.50    0    6
     1    2    4
     -49.05    -45.26    49.17    45.38    73.64    6.50    0    6
     1    1    5
     -49.05    -45.26    49.67    45.88    73.64    6.50    0    7
```

The following pages contain output results from the pgraph program for the VCRM example given in section 2.

4.1 TEST EXAMPLE OF PGRAPH PROGRAM (PLAN)

```
RUN PGRAPH
  Large Diameter Blasthole Mining
  Enter  1 for graphics output for a VCR stope
     or  2 for graphics output for an underground bench.
  ==>
```

1

```
 O U T P U T   D E V I C E   S E L E C T I O N

 --- ADVANCED TECHNOLOGY CENTER GRAFPAK GKS ---

 5301: FOR SUN 3/160 COLOR MONITOR
 5302: FOR SUN MONOCHROME MONITOR

 2501: FOR TEKTRONIX 4014

 6300: FOR IMAGEN LASER PRINTER 11*8.5 LANDSCAPE
 6301: FOR IMAGEN LASER PRINTER 8.5*11 PORTRAIT
 6302: FOR IMAGEN LASER PRINTER 14*8.5 LANDSCAPE
 6303: FOR IMAGEN LASER PRINTER 8.5*14 PORTRAIT

 1400: FOR CALCOMP 1042 PLOTTER 11*8.5 AT PLOTTER
 1401: FOR CALCOMP 1042 PLOTTER 17*11  AT PLOTTER
 1402: FOR CALCOMP 1042 PLOTTER 22*17  AT PLOTTER
 1403: FOR CALCOMP 1042 PLOTTER 34*22  AT PLOTTER
 1404: FOR CALCOMP 1042 PLOTTER 48*34  AT PLOTTER

 --- GRAPHIC SOFTWARE SYSTEMS GKS CSS*CGI ---:

 1    : FOR THE MONOTOR
 6    : FOR THE PRINTER
 7    : FOR THE PLOTTER
```

6300

```
  Do you wish to draw
   (1) A plan on a certain elevation
   (2) A cross section
   (3) Exit
   ==>
```

1

```
 ENTER OUTPUT FILE OF GRAPHIC DEFAULT: IMAGENGKS
```

plan.imp

```
Pick a plotting device for drawing
 Display (1) or
 Plotter (2) or
 Printer (3)
 ==>

3

  ENTER THE ELEVATION
  ==>

10650.0

      GRAFPAK-GKS, Copyright 1986
              Release 2.5
      Advanced Technology Center

           Licensed for use to:
                  EMR

  ENTER ANY CHARACTER TO CONTINUE :

c

  Do you wish to draw
   (1) A plan on a certain elevation
   (2) A cross section
   (3) Exit
   ==>

3
```

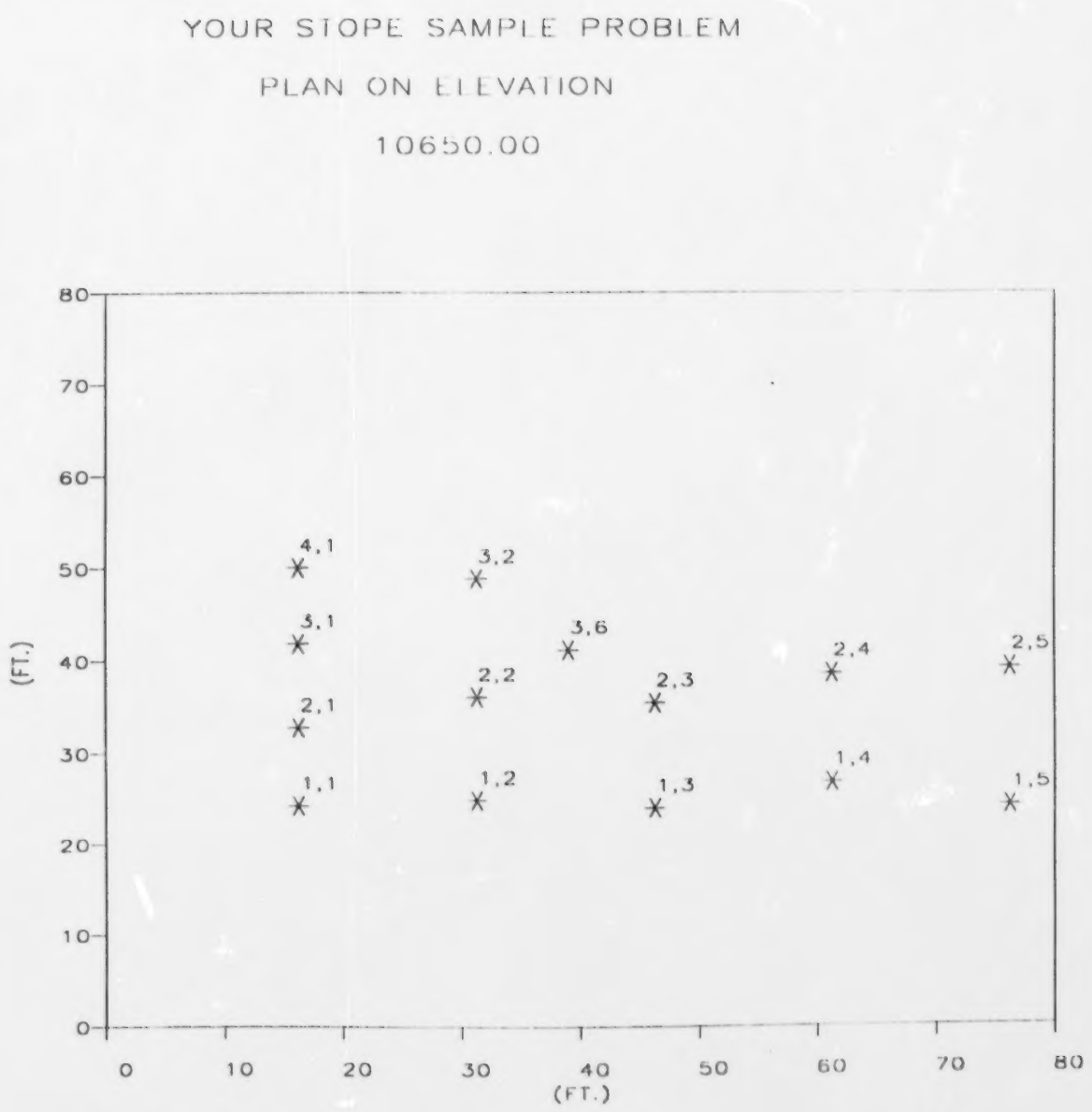


Figure 5: Plan of holes on elevation 10650.0

4.2 TEST EXAMPLE OF PGRAPH PROGRAM (CROSS SECTIONS)

```
RUN PGRAPH
  Large Diameter Blasthole Mining
  Enter  1 for graphics output for a VCR stope
     or  2 for graphics output for an underground bench.
  ==>

1

 O U T P U T   D E V I C E   S E L E C T I O N

 --- ADVANCED TECHNOLOGY CENTER GRAFPAK GKS ---

 5301: FOR SUN 3/160 COLOR MONITOR
 5302: FOR SUN MONOCHROME MONITOR

 2501: FOR TEKTRONIX 4014

 6300: FOR IMAGEN LASER PRINTER 11*8.5 LANDSCAPE
 6301: FOR IMAGEN LASER PRINTER 8.5*11 PORTRAIT
 6302: FOR IMAGEN LASER PRINTER 14*8.5 LANDSCAPE
 6303: FOR IMAGEN LASER PRINTER 8.5*14 PORTRAIT

 1400: FOR CALCOMP 1042 PLOTTER 11*8.5 AT PLOTTER
 1401: FOR CALCOMP 1042 PLOTTER 17*11  AT PLOTTER
 1402: FOR CALCOMP 1042 PLOTTER 22*17  AT PLOTTER
 1403: FOR CALCOMP 1042 PLOTTER 34*22  AT PLOTTER
 1404: FOR CALCOMP 1042 PLOTTER 48*34  AT PLOTTER

 --- GRAPHIC SOFTWARE SYSTEMS GKS CSS*CGI ---:

 1    : FOR THE MONOTOR
 6    : FOR THE PRINTER
 7    : FOR THE PLOTTER

6300

  Do you wish to draw
   (1) A plan on a certain elevation
   (2) A cross section
   (3) Exit
   ==>

1

 ENTER OUTPUT FILE OF GRAPHIC DEFAULT: IMAGENGKS

section.imp
```

```
  Pick a plotting device for drawing
Display (1) or
Plotter (2) or
Printer (3)
==>

3

  ENTER (1) FOR ROW SECTION
  OR    (2) FOR COLUMN SECTION
  ==>

1

  ENTER ROW NUMBER ==>

1

  DO YOU WISH TO DRAW THE CHARGES? (Y/N)

y

  ENTER 1 FOR DELAYS PLOTTED
        2 FOR CHARGE WEIGHTS
        3 FOR DEPTH OF CHARGE ALONG
          THE AXIS OF THE BOREHOLE
        4 FOR NO INFORMATION (WHEN
          HAVING LARGE HOLE DEVIATIONS)
  ==>

2

      GRAFPAK-GKS, Copyright 1986
               Release 2.5
      Advanced Technology Center

           Licensed for use to:
                    EMR
  Do you wish to draw
   (1) A plan on a certain elevation
   (2) A cross section
   (3) Exit
   ==>

2
.
.
.
.
```

Figure 6: Cross section of holes on row 1

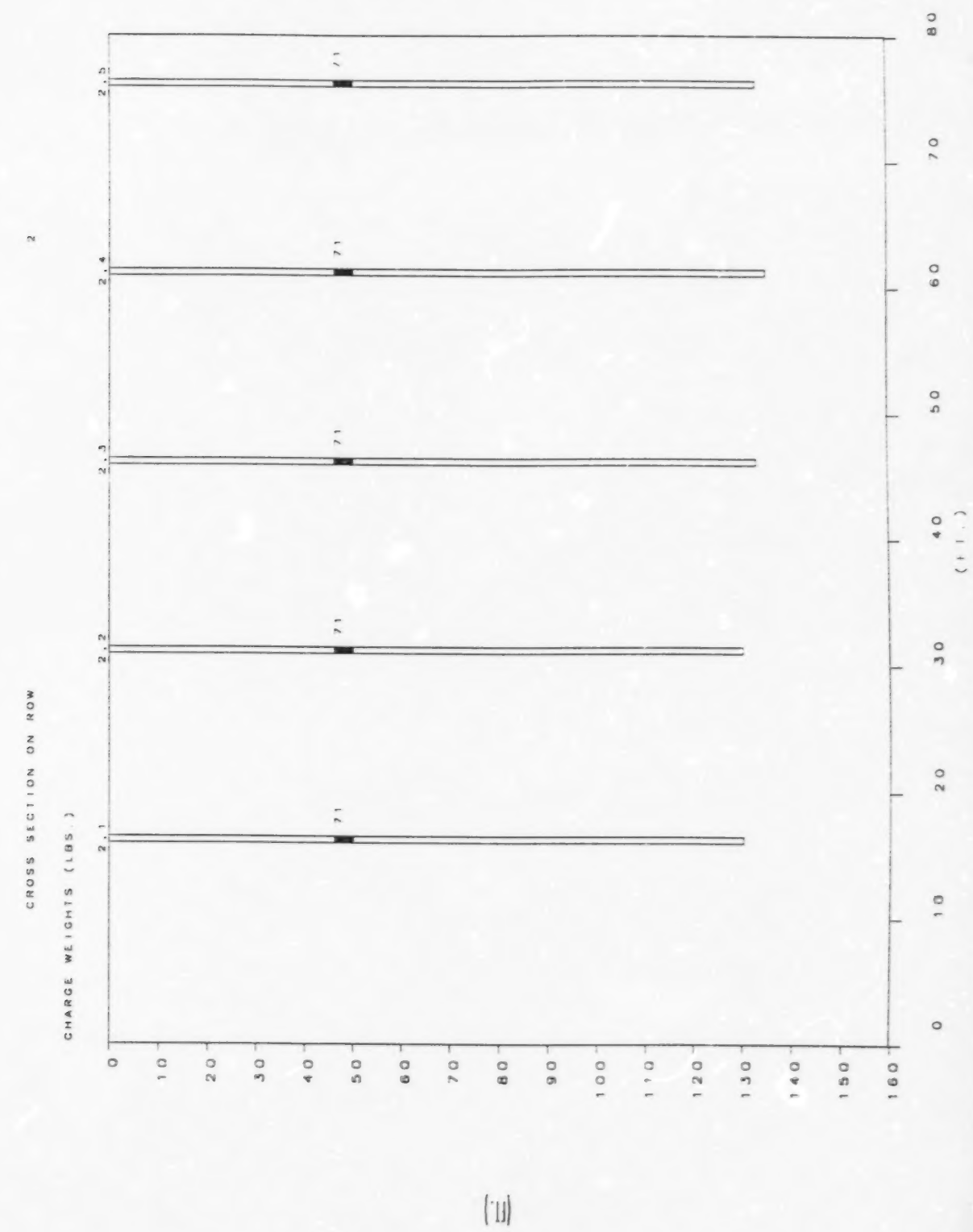


Figure 7: Cross section of holes on row 2

Figure 8: Cross section of holes on row 3

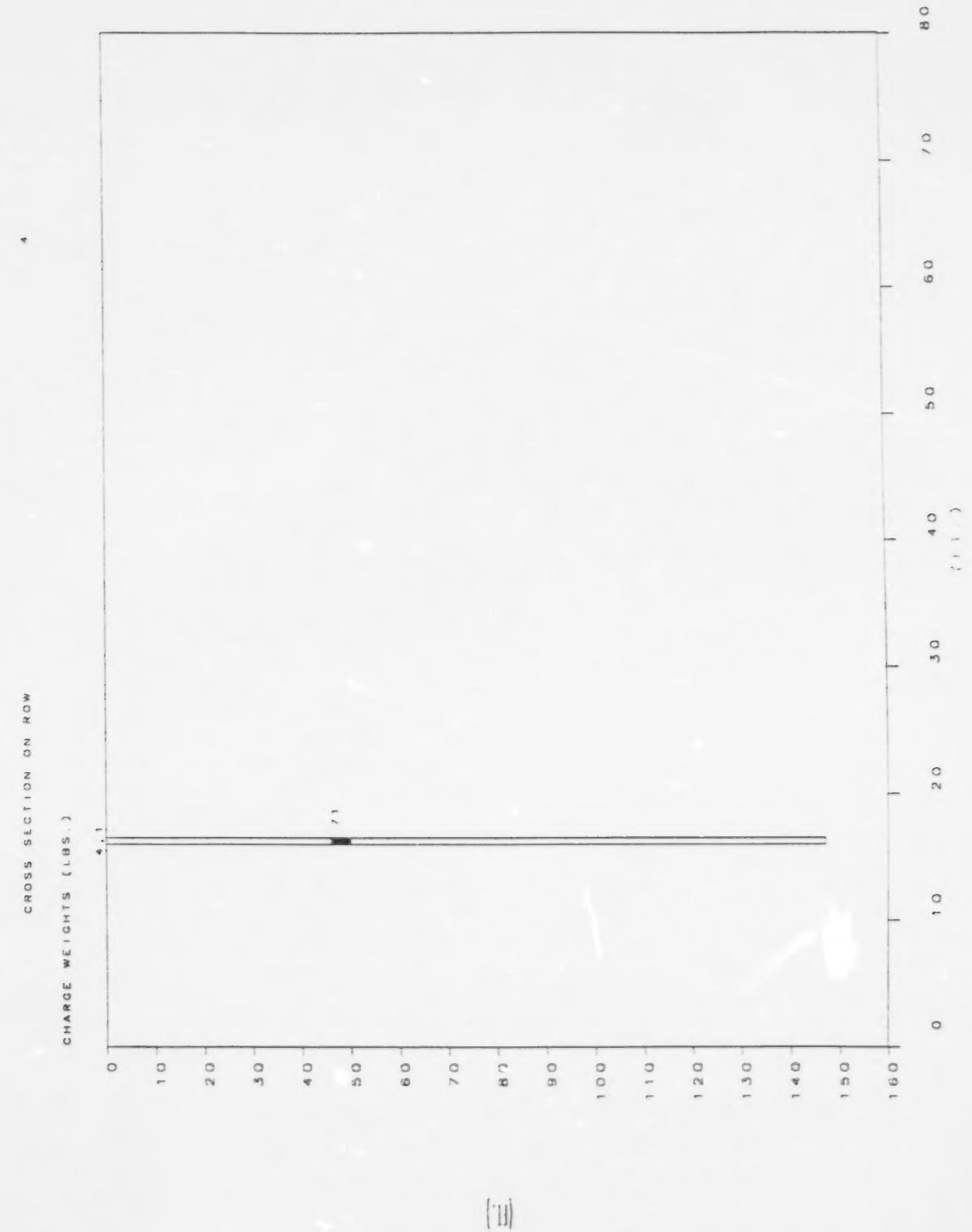


Figure 9: Cross section of holes on row 4

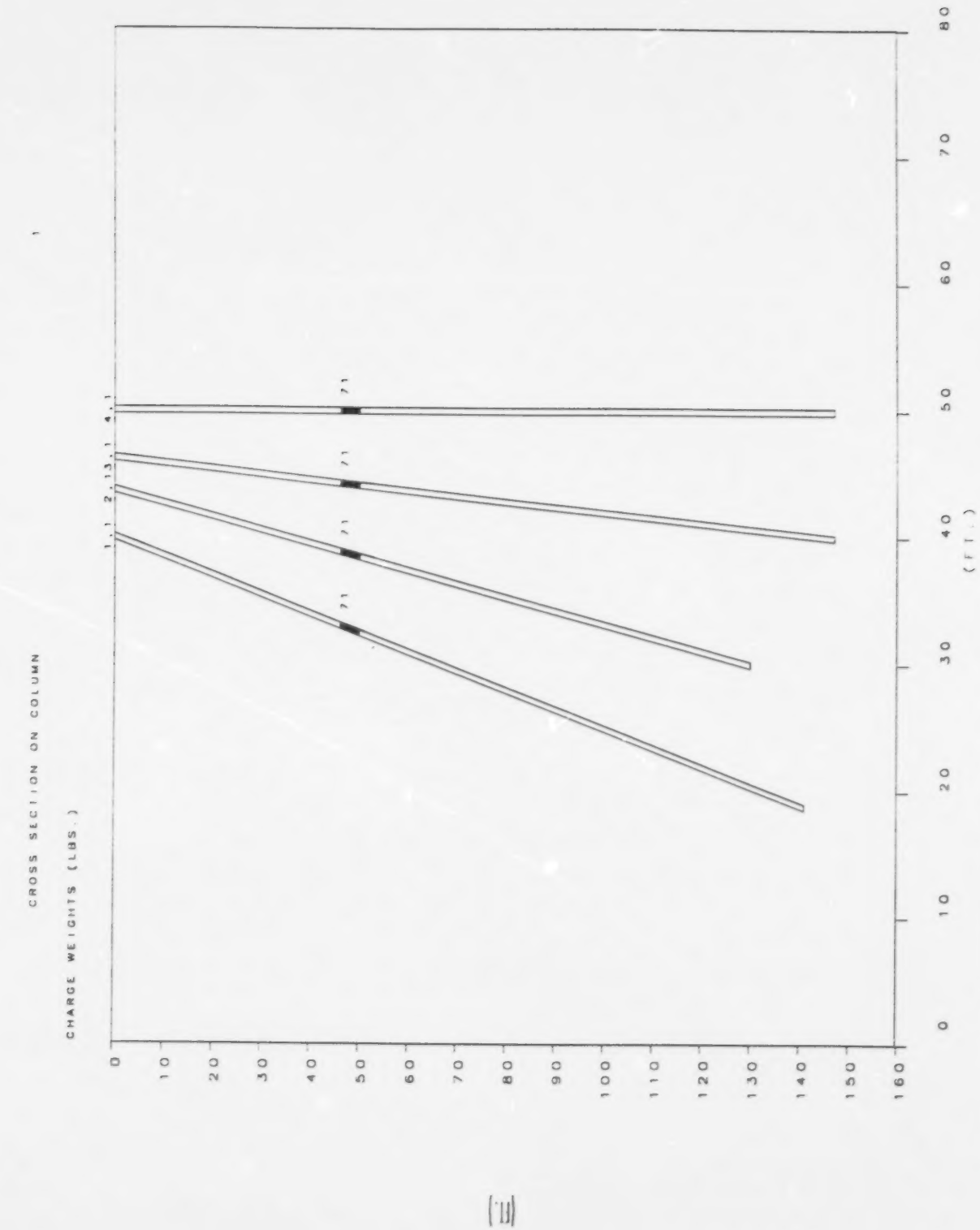


Figure 10: Cross section of holes on column 1

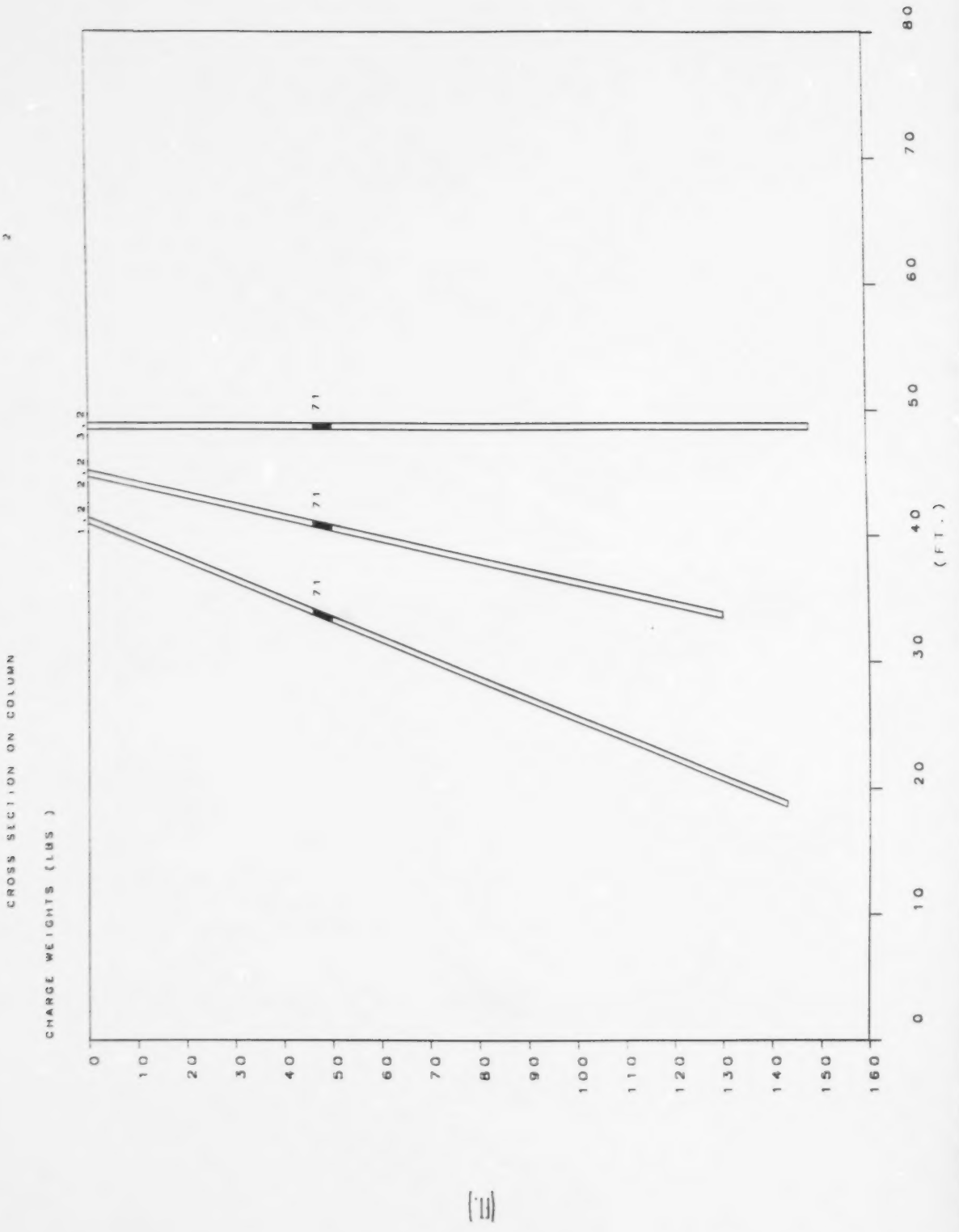


Figure 11: Cross section of holes on column 2

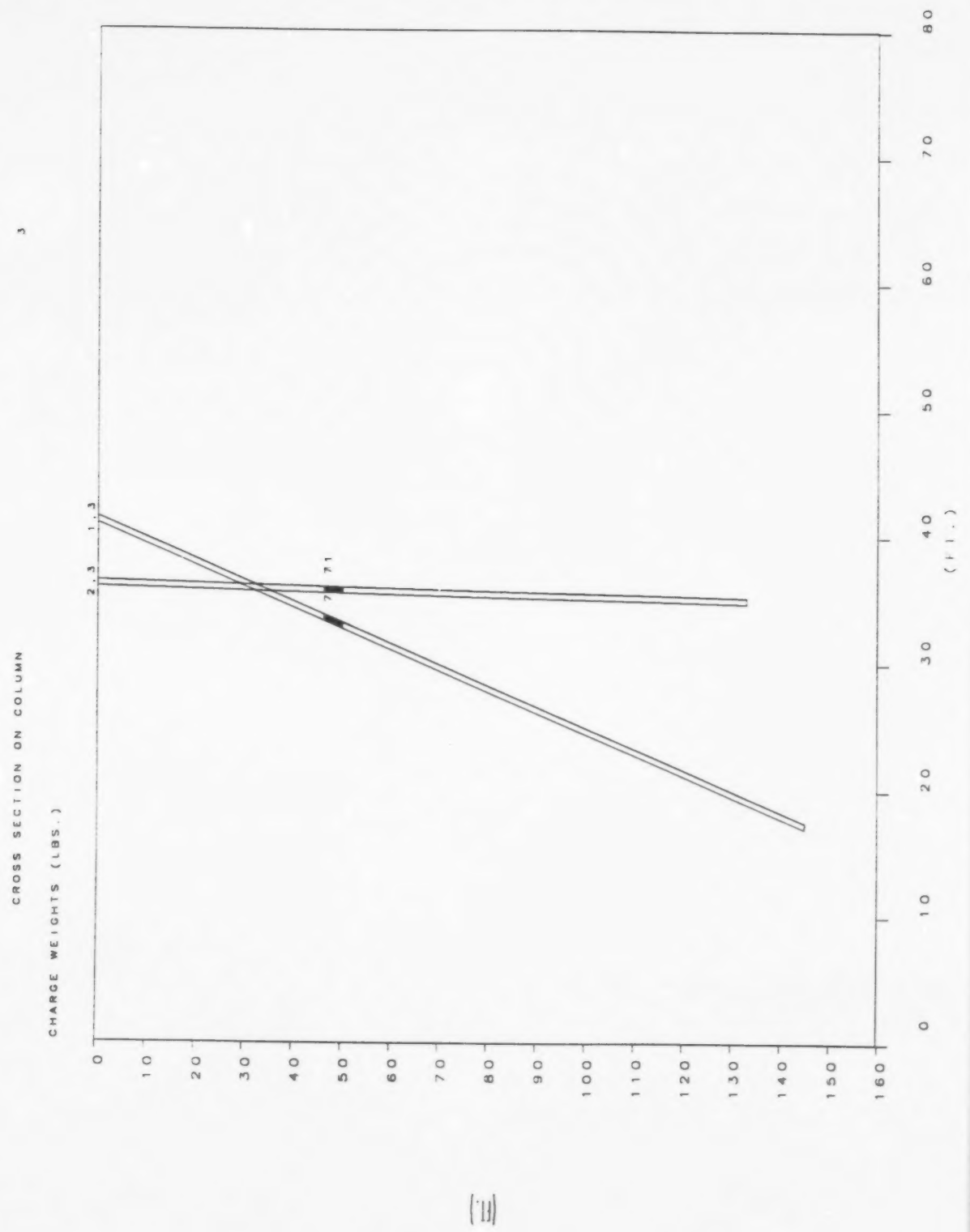


Figure 12: Cross section of holes on column 3

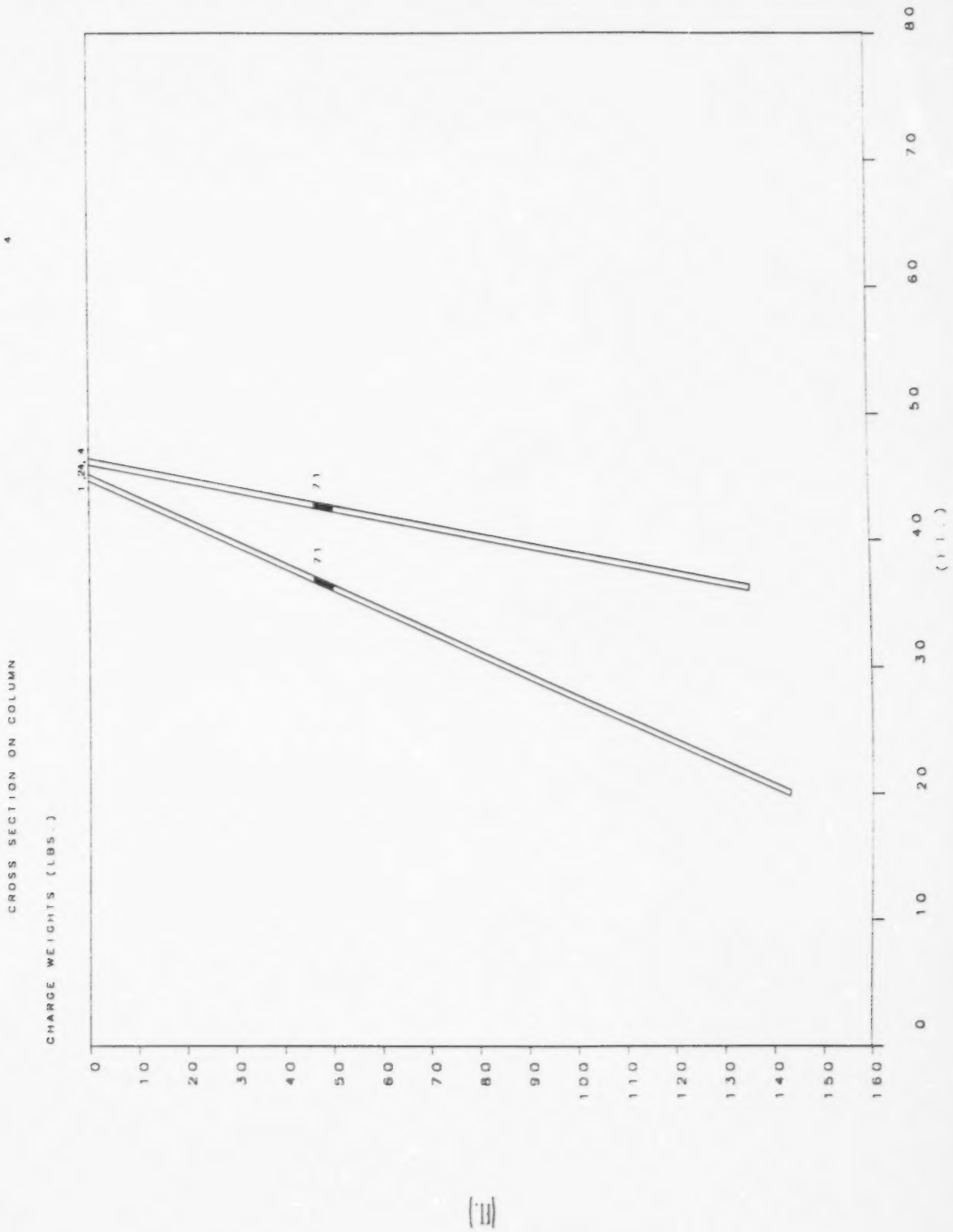


Figure 13: Cross section of holes on column 4

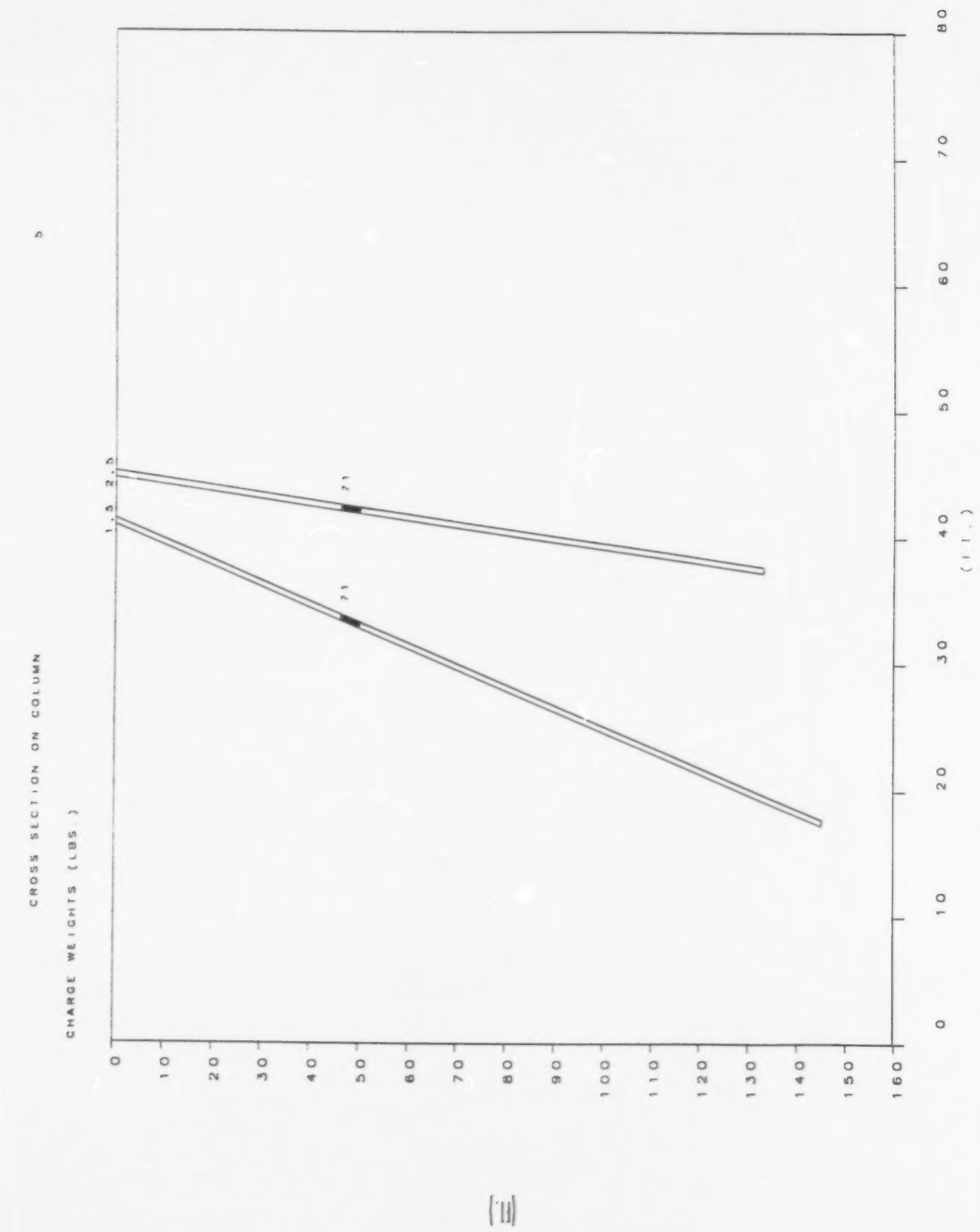


Figure 14: Cross section of holes on column 5